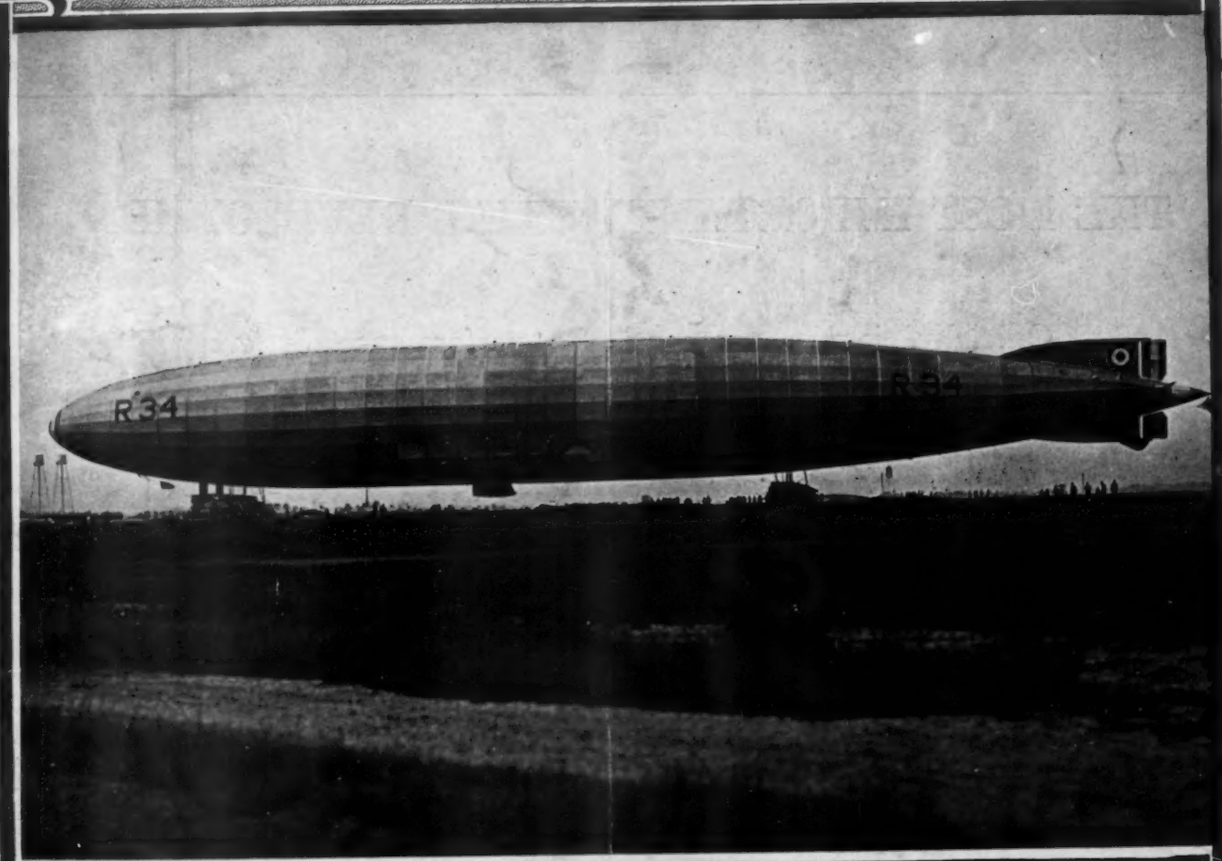
JULY 15, 1919 PRICE 25 CENTS

AVIATION
AND
AERONAUTICAL ENGINEERING



British Airship R 34 at Her Moorings in Roosevelt Field
(C) *Paul Thompson*

VOLUME VI
Number 12

Three Dollars a Year

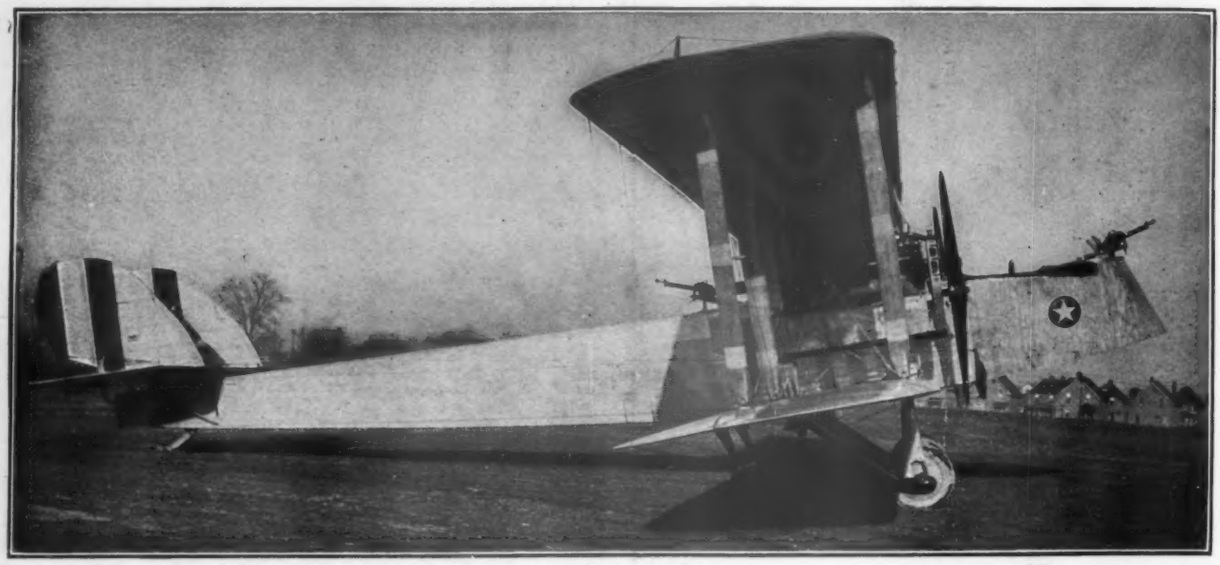
SPECIAL FEATURES

ALTITUDE ERRORS IN AERIAL NAVIGATION
BRITISH AIRSHIP R-34 DESCRIBED
GERMAN GIANT BIPLANE
COURSE IN AERODYNAMICS AND AIRPLANE DESIGN
MOISTURE PROOFING AIRPLANE PROPELLERS

RECEIVED
6 APR 1954

PUBLISHED SEMI-MONTHLY
BY
THE GARDNER-MOFFAT CO. INC.
HARTFORD BUILDING, UNION SQUARE
17 EAST SEVENTEENTH STREET NEW YORK

Entered as second-class matter August 8, 1916, at the



THE MARTIN NIGHT BOMBER

THE MOST IMPORTANT AERIAL DEVELOPMENT OF THE WAR

Officially, it has surpassed the performance of every competitor.

The forerunner of the wonderful

AERIAL FREIGHTER *and* TWELVE PASSENGER AIRPLANE

The skill and ability of the HOUSE OF MARTIN continue to maintain Supremacy of Performance and Dependability which they have held since 1909.

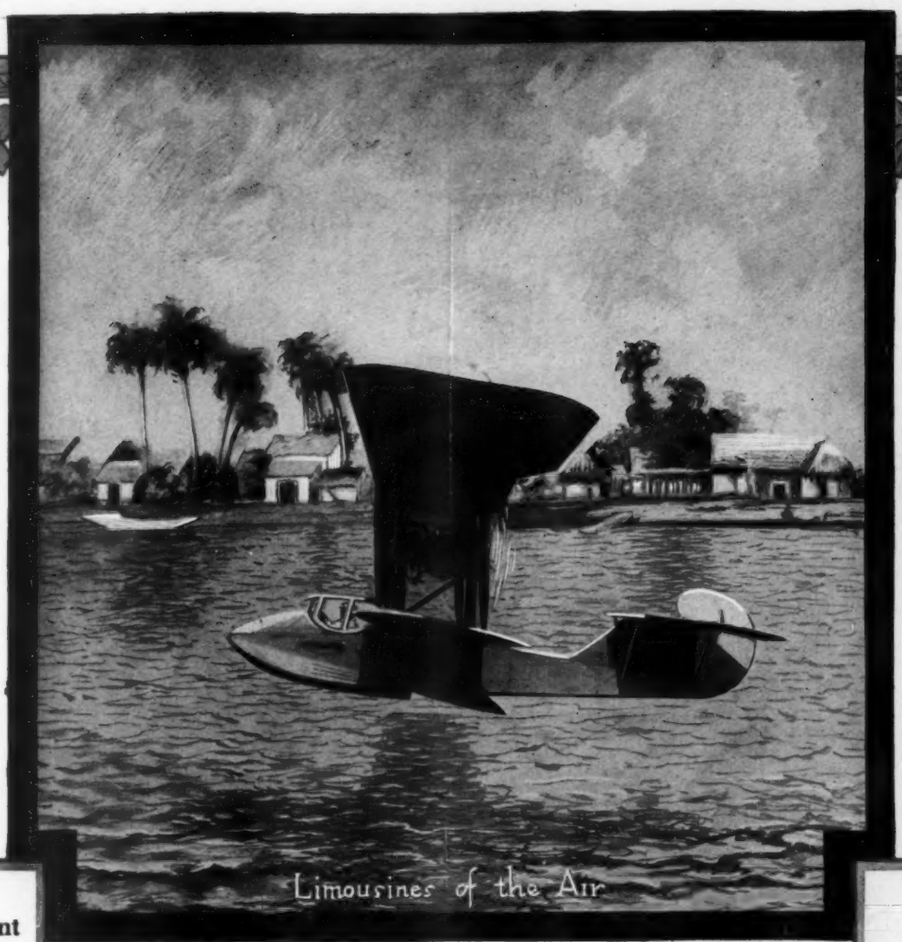
MARTIN U.S.A.

THE GLENN L. MARTIN COMPANY

CLEVELAND

Contractors to the United States Government

Aeromarine



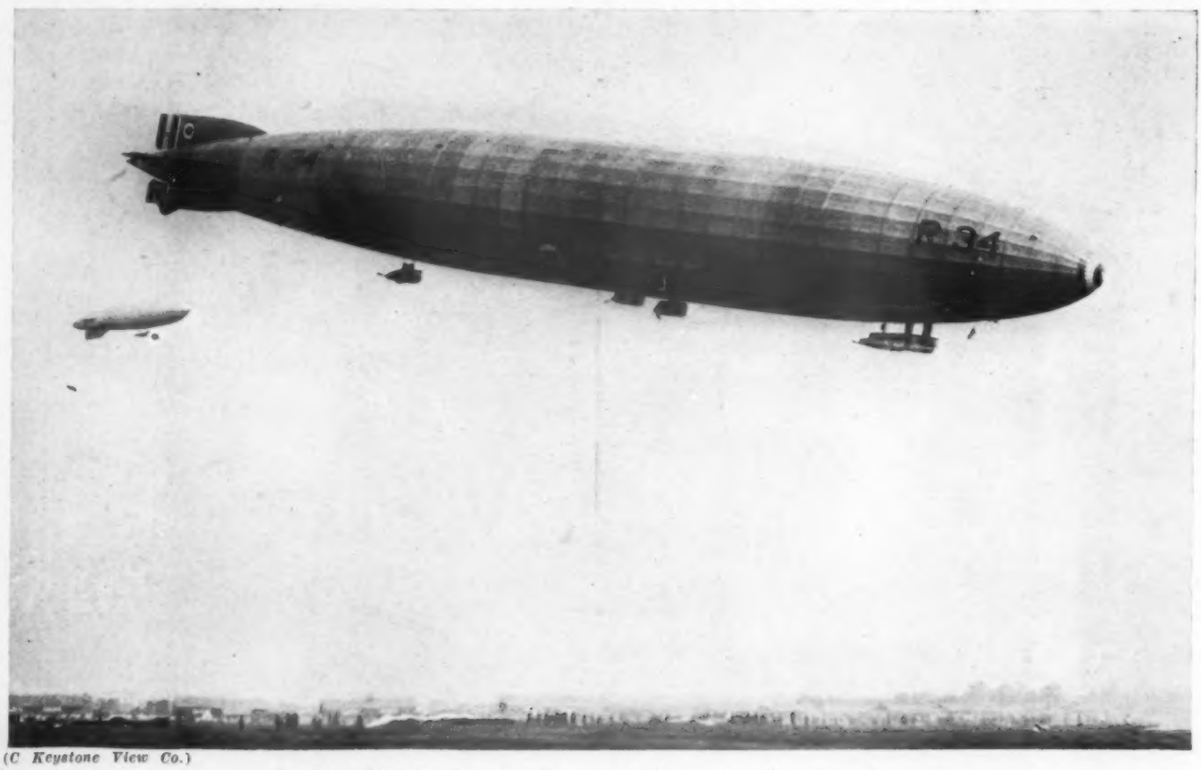
Sales Department
Times Bldg.
New York

Factory
Keyport
New Jersey

The experimental age of the airplane has been passed. With its part in the war now a bright epoch in history, the airplane is going to create history in the world of commerce.

Beardmore

BEST UNDER THE SUN



(C Keystone View Co.)

The R-34, Built by Beardmore, Lands in the United States.

The first lighter-than-air craft to cross the Atlantic
The first aircraft to cross the Atlantic from Europe to America

Total distance covered from East Fortune Air Station to Roosevelt Field, 3,130 sea miles.

Total duration of flight 108 hours and 12 minutes.

Hull and cars manufactured and assembled by Beardmore

In conquering the Atlantic Ocean, the R-34 has inaugurated the era of safe and dependable trans-oceanic air transportation.

Inquiries from American interests will be given careful attention.

WILLIAM BEARDMORE & CO., LTD.

112 Great Portland Street, London, W. 1.

FAME

CDC

A close-up photograph. Note landing gear and special strut construction affording self-alignment.

THE ACE

The most encouraging sign of the future of aviation is the large number of former army and navy flyers who are coming back into flying for sport, and as a profession.

The war was responsible for the rapid training of many thousand men—the best blood of the nation—who are generally recognized as the most skillful, resourceful and daring pilots in the world.

When these men left the service, their interest in flying did not cease. On the contrary, they are more eager to fly than ever before. The call of the air is irresistible. They will fly, henceforward, just as in past years they played polo, and owned speed boats, and rode to hounds, and took part in other man's-size sports and occupations.

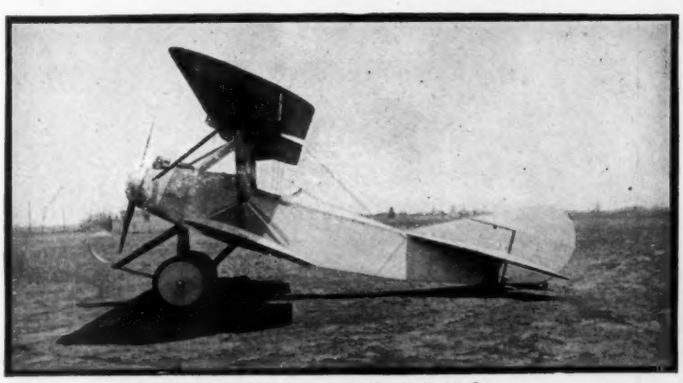
For the benefit of these men, and their friends, a group of aeronautic engineers and others keenly interested in aviation foresaw the tremendous present-day need for a reliable and practical light airplane, and have proceeded to build and test a plane that would meet these requirements.

This plane is The Ace. It is ready for you now.

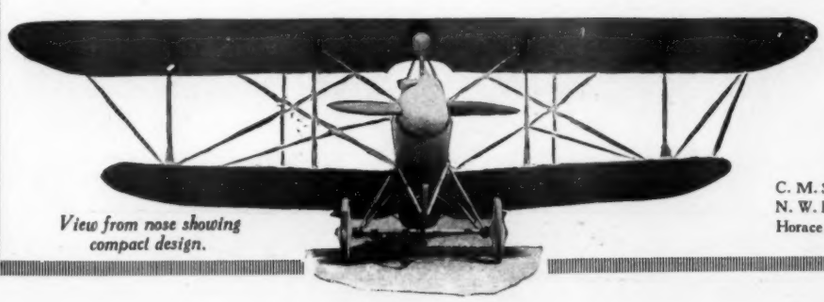
PRICE $2,500

Write for new folder, containing pictures and specifications of The Ace—the first American airplane designed after the war essentially for civilian use—and the most practical and safest small ship ever built for the man who wants to fly frequently, regularly, and at a minimum of expense.

The Ace about to take off. Lt. Murchie, pilot.



Outside hangar, ready for daily flight.



View from nose showing compact design.

AIRCRAFT ENGINEERING CORPORATION

Sales Offices: 220 W. 42d St., New York
Flying Field, Central Park, L. I.

C. M. Swift, Gen. Mgr. — General Offices, 2 East End Ave.
N. W. Dalton, Chief Engr. — Factory A, 535-37 E. 79th St.
Horace Keane, Sales Mgr. — Factory M, 417-19 E. 93rd St.

ROLLS-ROYCE

THE FUTURE OF FLYING DEPENDS ON RELIABILITY

A telegram from Captain Alcock and Lieutenant Brown reads:

"Congratulations on performance of the two Eagle Rolls-Royce engines which propelled the Vickers Vimy safely across the Atlantic."

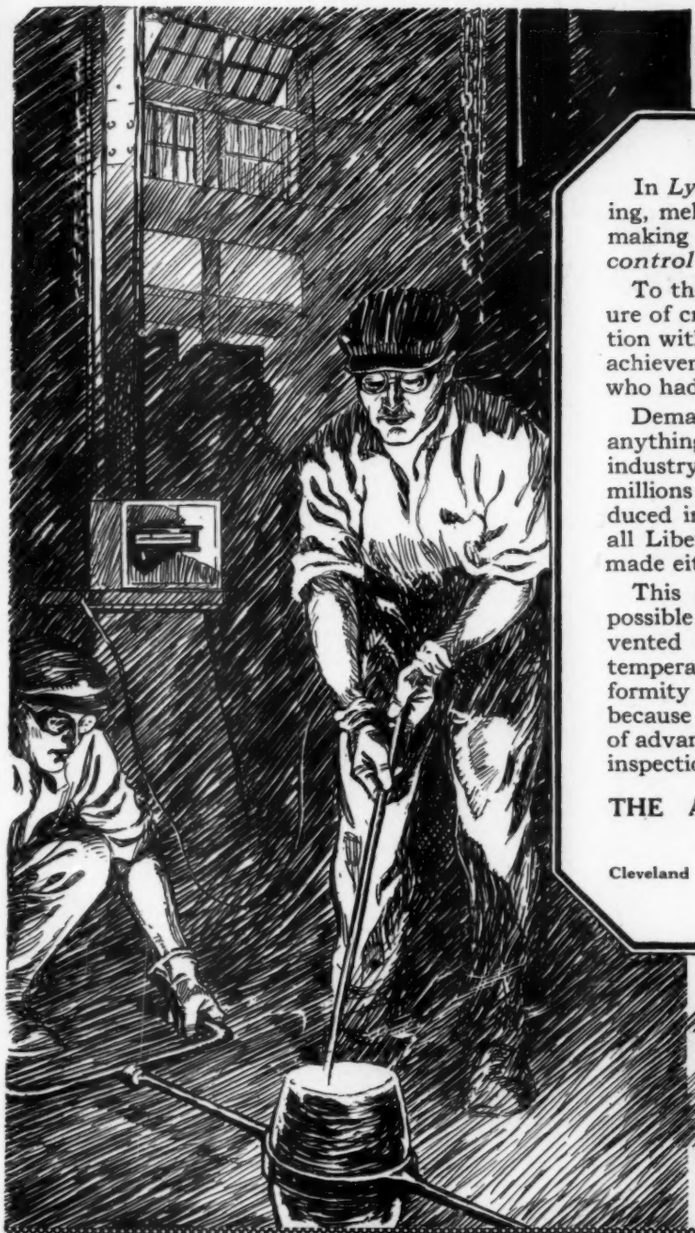
ROLLS-ROYCE AERO ENGINES LIKE ROLLS-ROYCE CARS

THE BEST IN THE WORLD

ROLLS-ROYCE

Certainty—

from Crucible to Casting



In *Lynite* foundries, guesswork is barred. Mixing, melting, pouring—in short, every step in the making of a casting—are under *strict scientific control.*

To this exactness of control is due a large measure of credit for *Lynite's* achievements in connection with the Liberty Engine. The extent of these achievements is appreciated, perhaps, only by those who had a part in the production of these engines.

Demands for quality and quantity far exceeding anything in the history of the aluminum alloy industry were successfully met. Two and one-half millions of castings, totaling 5374 tons, were produced in *Lynite* foundries, eighty-five percent of all Liberty engine aluminum alloy castings being made either of *Lynite* or to *Lynite* formulae.

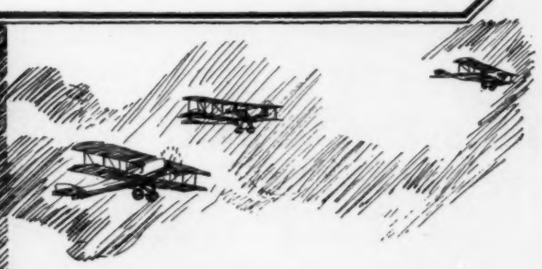
This production record would not have been possible without the scientific control which prevented even the slightest variations in pouring temperatures, for example, and insured that uniformity so vital to airplane engine parts. Largely because of this thorough and careful application of advanced foundry methods the rigid government inspection found remarkably few castings to reject.

THE ALUMINUM CASTINGS COMPANY

LYNITE and LYNUX Castings

Plants in

Cleveland Buffalo Detroit Fairfield, Conn.



LYNITE

"NORMA" PRECISION BALL BEARINGS

(PATENTED)

Out of after-the-war conditions, some words are emerging with new and trenchant meanings—among them, "value" and "service" and "price." American machine builders and buyers know today as never before, that value must be measured by service, not by price. Any other standard is a false one, sure to lead to disappointment.

The airplanes, cars, trucks, tractors and power boats that to-day are commanding the market on service rather than on price, carry "NORMA" equipped magnetos and lighting generators. Which simply confirms the statement repeatedly made in this space that "NORMA" Bearings are an identifying feature of high-duty, long-service automotive units.

Be SURE—See that your Electrical Apparatus is "NORMA" Equipped

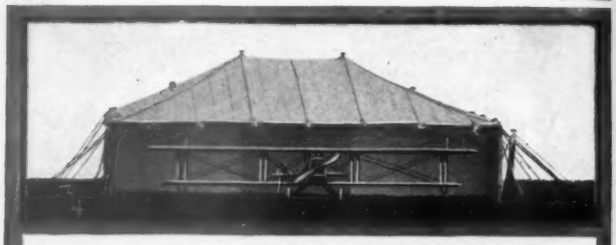
THE NORMA COMPANY OF AMERICA

1790 BROADWAY NEW YORK

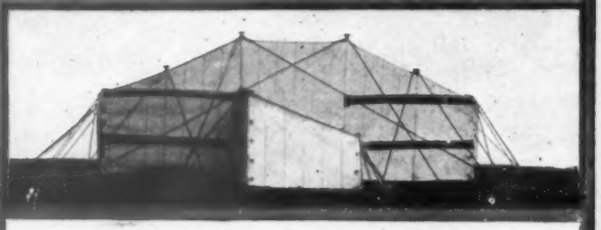
Ball, Roller, Thrust and Combination Bearings.

Portable Hangars For JN-4 Curtiss

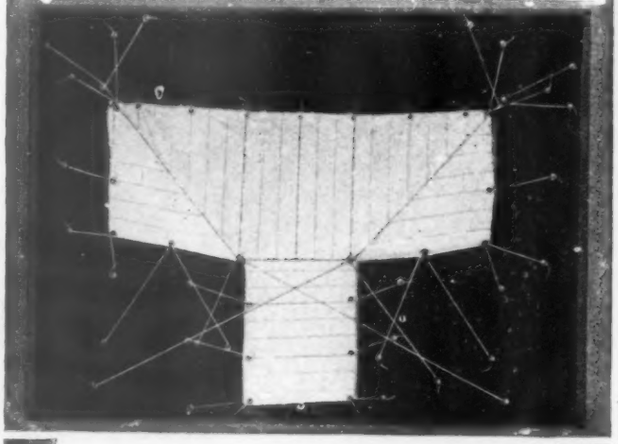
Best of Material and Workmanship
Fit like the glove to the hand.
Simple as A—B—C.



Airplane in hangar. Note room for camp beds on each side under top plane. Front wall closes on cable at top and lashes in center. Iron pins at bottom make it wind and rain proof.



Balance of power for wind resistance through double crossed guys removes strain from any one point, and insures perfect safety in storms.



Careful tests of canvas strength have proven the value of rope reinforcements. The heavy guys shown are built into the hangar.

ALL PATENT RIGHTS PROTECTED
MANUFACTURED ONLY BY

Foster & Stewart Company

371-3-5 Pacific Street
BROOKLYN, NEW YORK
Phone, Main 6827

JULY 15, 1919

AVIATION
AND
AERONAUTICAL ENGINEERING

VOL. VI. NO. 12

Member of the Audit Bureau of Circulations

INDEX TO CONTENTS

	PAGE
Editorials	623
Altitude Errors in Aerial Navigation	624
Notes on Balloon Fabrics	626
Ventilated Spark Plug	627
New York-Chicago Air Mail	627
Electric Arc Welding in Aircraft Construction	628
The Fiat BR Long Range Bomber	628
British Airship R-34 Described	629
Giant D. F. W. Biplane	632
Course in Aerodynamics and Airplane Design	633
Moisture Proofing Airplane Propellers with Aluminum Leaf	636
The Bristol Triplane Braemar	639
Airplane and Seaplane Engineering	640
Book Review	643
The Air Service Parachute	644

THE GARDNER - MOFFAT COMPANY, Inc., *Publishers*

HARTFORD BUILDING, UNION SQUARE, 22 EAST SEVENTEENTH STREET, NEW YORK

WASHINGTON OFFICE, EVENING STAR BUILDING

SUBSCRIPTION PRICE: THREE DOLLARS PER YEAR. SINGLE COPIES TWENTY-FIVE CENTS. CANADA, THREE AND A HALF DOLLARS: FOREIGN, FOUR DOLLARS A YEAR. COPYRIGHT 1919, BY THE GARDNER-MOFFAT COMPANY, INC.

ISSUED ON THE FIRST AND FIFTEENTH OF EACH MONTH FORMS CLOSE FIVE DAYS PREVIOUSLY. ENTERED AS SECOND-CLASS MATTER, AUGUST 3, 1916, AT THE POST OFFICE AT NEW YORK, N. Y., UNDER ACT OF MARCH 3, 1879.

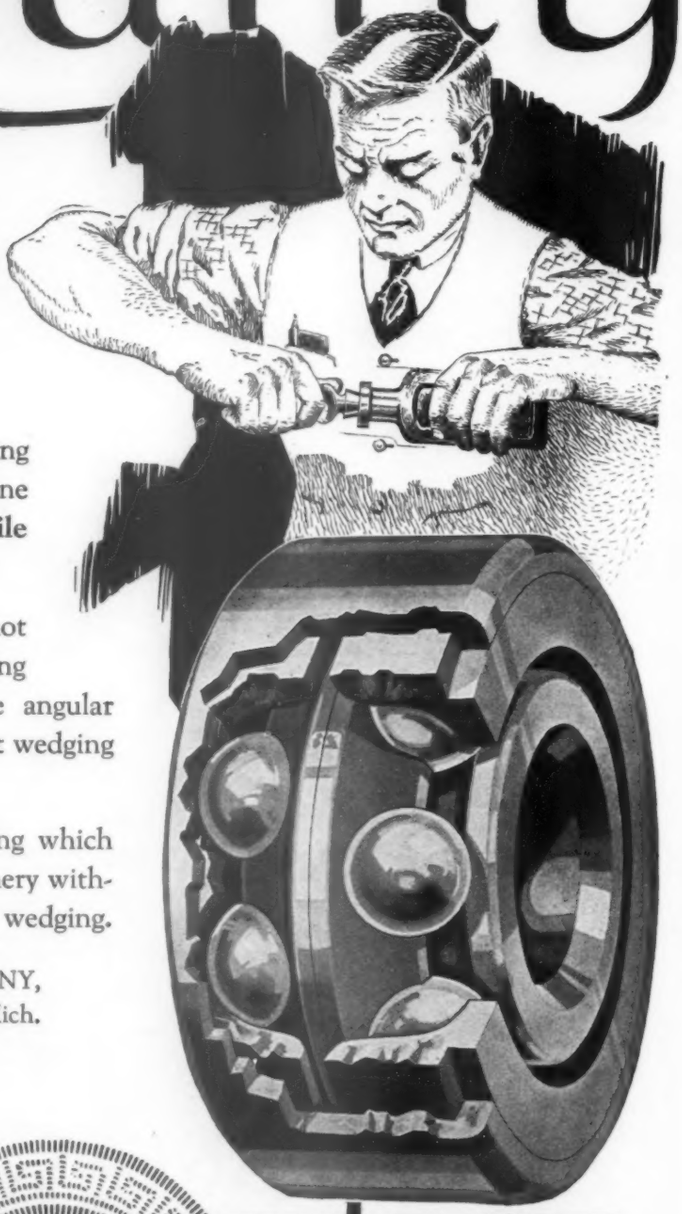
AEROPLANE CRANKSHAFTS

WYMAN-GORDON COMPANY

"The Crankshaft Makers"

Worcester, Mass. Cleveland, Ohio

Quality



TRY to revolve a tapered stopper in a bottle **while pressing inward.** The harder you press, the harder it turns, because of the wedging action with its resultant friction.

Repeat this operation with the ball bearing illustrated, holding the outer member in one hand and rotating the inner member **while pressing inward** as before.

You find that the ease of rotation is not impaired by the end thrust. The ball bearing turns quite freely, for the New Departure angular contact bearing absorbs end thrusts without wedging action and its consequent frictional drag.

The **ball** type is the **only** form of bearing which resists these end-on loads in modern machinery without loss of power due to the friction of wedging.

THE NEW DEPARTURE MFG. COMPANY,
Bristol, Conn. Detroit, Mich.

448

New Departure Ball Bearings

L. D. GARDNER
PRESIDENT AND EDITOR
W. D. MOFFAT
VICE-PRESIDENT
W. I. SEAMAN
TREASURER
H. M. WILLIAMS
GENERAL MANAGER

AVIATION
AND
AERONAUTICAL ENGINEERING

ALEXANDER KLEMIN
TECHNICAL EDITOR
LADISLAS D'ORCY
ASSOCIATE EDITOR
GEORGE NEWBOLD
BUSINESS MANAGER

Vol. VI | July 15, 1919 | No. 12

THE 3,200-mile voyage of the British airship R-34 from Scotland to the United States, accomplished in the face of strong head winds and violent atmospheric disturbances, is an event comparable in its significance with the first crossing of the Atlantic by a steamship, just one hundred years ago.

Considering that the prevailing winds in the Northern Atlantic blow from the western quarter, aircraft passages from Europe will always be handicapped by head winds and take more time than eastward trips. This is why all but one of the British transatlantic airplanes were scheduled to start from Newfoundland, so as to acquire acceleration from following winds. Therefore the epoch-making voyage of the R-34 is not only a brilliant vindication of lighter-than-air craft with regard to their ability to cover great distances without alighting; it also proves that airships can successfully overcome the most severe weather conditions and reach their destination despite delays due to head winds. That these delays are fatal to airplanes and seaplanes, particularly in ocean flights, is the opinion of the first victor of the Atlantic, Commander Read, who pronounced the flight of the R-34 the most important of three successful Atlantic flights.

This voyage is the more remarkable if it is considered that it was undertaken without previous knowledge of the atmospheric conditions which prevail over the Atlantic; the experiences of the R-34 will therefore prove of considerable value to meteorological experts and serve as a working basis upon which the charting of the oceanic atmosphere may be begun. Such work would be of the utmost importance for the future of oceanic air navigation and should be, if possible, jointly undertaken by the nations most concerned in it, that is, the United States, Great Britain and France, which, being separated by the Atlantic, would benefit the most by having it spanned by swift and safe aerial services.

The first transatlantic flight by lighter-than-air craft and the first aerial passage to the westward thus assumes the importance of a true pioneer achievement which will immortalize the names of Major Scott and his crew and further strengthen the bonds of friendship between Great Britain and the United States.

Armament and Accessories

Prior to the War and in the initial stages of the War, the airplane was a simple machine equipped with an engine, a propeller, engine controls and plane controls, seating arrangements for a passenger and pilot. An altimeter and an air speed indicator were sometimes carried.

Now we find the airplane carrying an enormous amount of equipment. For navigational purposes, compasses, altimeters, air speed indicators, drift indicators, banking and longitudinal inclinometers are almost invariably carried. Oxygen tanks have to be provided for altitude purposes.

Parachutes will most certainly be required in the near future.

Armament on a military machine involves a whole design in itself. Sights, ammunition boxes, turrets, feeders, ejectors, have to be provided. In a military machine, it is no longer a question of designing an airplane pure and simple, it is a question of designing a machine round the equipment and armament to be carried.

No designer can afford to neglect this point of view in the initial stages of his work.

Municipal Aerodromes

The lead taken by the city of Albany, N. Y., with the establishment of the first municipal aerodrome in the United States, may soon be followed by New York City, whose Board of Estimate is discussing the advisability of creating a municipal landing station for aircraft.

No scheme could be more timely in view of the rapid development of aircraft. Although there are several excellent landing fields in the neighborhood of New York, the need for a municipal aerodrome, so located as to be easily and quickly accessible from any borough of the great metropolis, is obvious, for such an arrangement would greatly reduce the loss of time incurred in travelling to and from the present landing fields. The Post Office Department fully realized this when it moved its aerial mail terminus from Belmont Park to Newark, N. J., whence the Hudson tube greatly shortens delivery of the airborne mail.

A point worth consideration in the planning of a municipal aerodrome for New York is that it should be of great proportions, or at least be capable of considerable expansion, so ample facilities will be available for future increases of aerial traffic.

At the same time some provision should be made for reserving a certain area in New York harbor as a seaplane landing station; this would prove very useful to pilots engaged in coastwise flying, provided the station is free from encumbrances and has sufficient frontage for taking off.

Altitude Errors in Aerial Navigation

A New Form of Barograph for Their Avoidance

By J. G. Coffin

Assistant Director of Research, Curtiss Engineering Corp.

All flying machines and airships are at present provided with some form of barometer, either registering or not, for navigating or testing purposes. These instruments are usually of the aneroid type and their indications are supposed to give the altitude of the machine during its flight. Their indications are generally taken for granted as being accurate after allowances for zero reading at ground level and for temperature are made. The altitude is some function of the static air pressure at the point whose altitude is desired. The exact relation between height and static pressure can be expressed by a well known formula and corrected for temperature. For the formula and corrections to be applied reference is made to

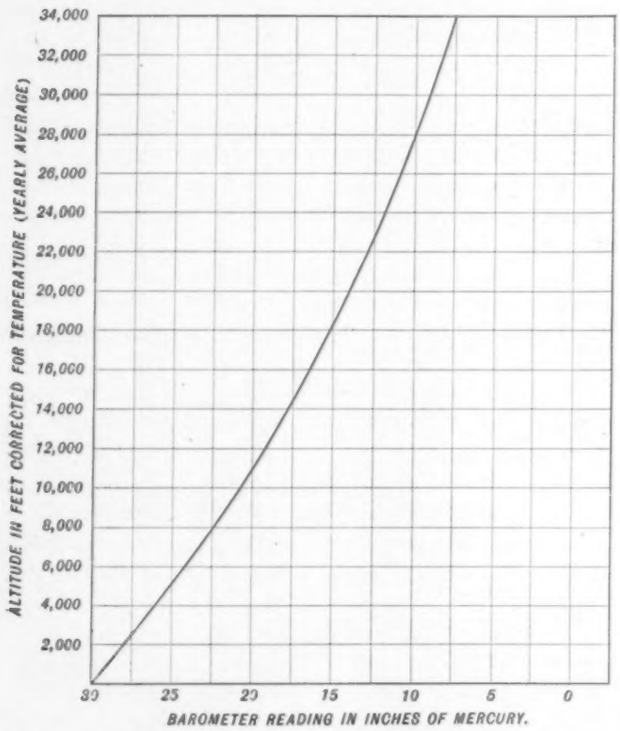


FIG. 1. ALTITUDE-PRESSURE CHART CORRECTED FOR AVERAGE YEARLY TEMPERATURES

the Smithsonian meteorological tables. It is better and more reliable, however, to use the results of the extensive observations carried on in various countries with sounding balloons. A graph showing the most probable relation between the barometric reading and altitude can be given and is to be preferred to the formula.

The exact altitude of a machine can, of course, be obtained by ground observations with surveying instruments but this method is evidently a complex one, is restricted to a given locality and requires several observers and simultaneous observations, and is for practical reasons out of the question. The practical requirements reduce themselves then to that of obtaining the true static pressures during the flight, the transformation of these pressures to corresponding altitudes being taken care of as above described.

We shall assume that the instrument is a perfect one, correctly registering the pressure acting on it, so as to bring out more clearly other errors of its use as contemplated here. The great objection here referred to in the use of existing instruments is not that they do not record the pressure of the air in a given region acting on them but that this pressure is not the true static pressure, there being an error which is a function of the speed of the machine, the position of the instrument in the machine and the air density. This error is by no means negligible. For example, at a speed of 60 m.p.h., which today is not over the usual landing speed of a fast machine, the error may amount to over 240 ft., and at 120 m.p.h., a common air speed at the present time, it may be over 1,000 ft. For a pilot flying in a haze or in clouds it is of prime importance that he know his height above the ground much more closely than these figures, for he may think himself flying well up and may be actually in dangerous proximity to the ground and liable to a serious accident.

The barometer is usually enclosed in a box or case but this case must have an opening to the external air so as to permit of the communication of the surrounding air pressure to the instrument. If the box is airtight except for a single opening, for example, this aperture may be directly facing the air stream, in which case the pressure within the box and, therefore, registered by the instrument is static pressure plus the aerodynamic pressure corresponding to the speed of the air at that time. If the opening is on the side it may have a value more nearly the correct one or much worse,* but observations show large fluctuations. If the opening is in the rear, the instrument records a pressure considerably less than static by an amount which in many cases is as great as the direct aerodynamic pressure and sometimes even greater. The pressures indicated by a barograph placed within a spherical box and for various orientations of this opening are shown in the diagram Fig. 2. These measurements were made in one of the Curtiss wind tunnels at Garden City.

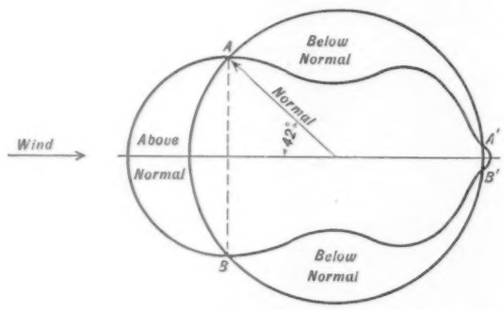


FIG. 2. DISTRIBUTION OF PRESSURE AROUND A SPHERE IN A CURRENT OF AIR

Radial distances greater than the radius indicate pressures greater than normal static pressure; radial distances less than the radius correspond to pressures less than normal static pressure. On the diagram the pressure graph crosses normal at the points A and B and also at two points A' and B' in the rear. This means that if the aperture through which the pressure is communicated to the barograph were at any point on the circle of which AB is the trace, the indications should be correct. There is no doubt that they would be nearer normal than if the aperture were placed directly ahead but the rate change of pressure at these points on the circle is a maximum and larger fluctuations are liable to occur and do occur. Again there is another objection in that the actual direction of wind flow on a body placed on a flying machine is hard to determine as shown by the difficulty of finding a reliable position for a wind speed indicator.

Several years ago Dr. A. F. Zahm† proposed that the barograph case consist of a streamline body and that the barometer be hermetically sealed therein except for a connection to an

* Cases have been observed where the negative aerodynamic pressure at the side was nearly three times the maximum postive pressure. This corresponds to a possible error of 2500 ft. in altitude at 120 m.p.h.

† Journal of the Franklin Institute, May, 1913, pp. 503.

aperture at a point of normal static pressure such as A. Fig. 3, taken from this paper, shows the pressure distribution around a streamline body. The barograph and connection to point A has been added to the drawing. It is to be noticed that the connection could also be made to A'. The fluctuations of pressure in this region, however, are very large and this position for the aperture has not been proposed. As far as this method of overcoming the difficulty is concerned, the writer

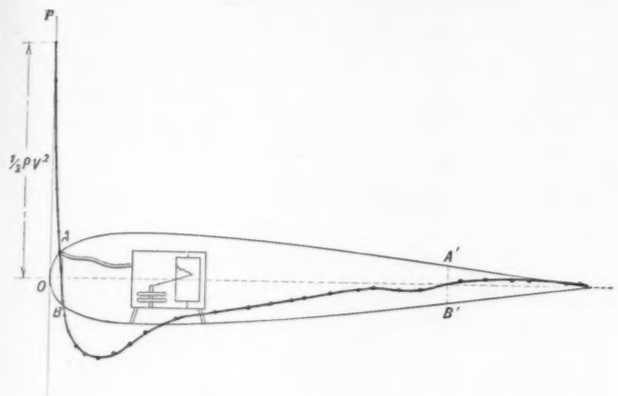


FIG. 3. DISTRIBUTION OF PRESSURE AROUND A STREAMLINE BODY

believes that if the barograph were connected to the static openings of a standard Pitot tube properly placed on the machine, the indications would be as reliable as the one just proposed. The main objection, however, to this method is that the proper position of the streamline body or static opening of the Pitot tube is indefinite and hard to find and when found might be in a very inconvenient place. The instrument to be described below in this article overcomes all of these difficulties besides having other attendant important advantages.

A natural observation when these barometers errors are brought to the attention of anyone is that the barograph is usually placed in the fuselage and is, therefore, protected from the air stream and hence these objections do not apply. This reasoning is fallacious. There is no advantage to be derived from placing the instrument case inside of another case because this outside case must also be open to the air, the static pressure of which we are measuring, and the pressure inside of this case depends, just as before, on the position of the opening. The pressure measured by the barograph is always that obtaining at the opening of the outside box.

Now, the fuselage is just such a box and as its opening to the air is mainly through the cockpit, the pressure measured is not only incorrect and indefinite, but is subject to large variations due to the movement of the occupant. A new form of pressure indicating device overcoming all of these objections consists in placing any form of pressure indicating instrument inside a container, for instance, a sphere, with an opening to the outside air and rotating or oscillating the container so as to periodically cover the entire 360 deg. The rotations or oscillations are of equal periods say one in five seconds.* On an airplane at any constant altitude the barograph will register a graph similar to that shown in Fig. 4.

In this figure where the two curves, taken from actual tests, correspond to measurements at two different air speeds it will be noticed that if the aperture is 45 deg. either side of the head-on position the observed pressure is normal or true static. At about 90 deg. the pressure has become negative by an amount greater than the pressure at head-on position.

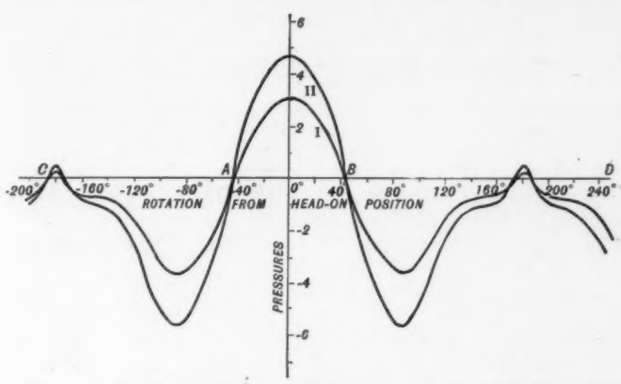


FIG. 4. GRAPH SHOWING CURVE OF PRESSURES INDICATED BY A BAROGRAPH PLACED WITHIN A SPHERE AND ROTATED IN AN AIR STREAM FOR TWO DIFFERENT AIR SPEEDS

The zero line of this graph is perfectly definite and can be found experimentally in any case. Even if fluctuations do occur the zero line is still definite because it is determined by the average of a large number of rotations of the barometer case. It is evident, since the pressure graph for any given instrument is to be defined by experiment, that the shape of the container is of no consequence as far as this method is concerned and, therefore, can be of the most convenient one, either aerodynamically or structurally, a short cylinder or a small sphere being found at present most convenient. It is also evident, if the connection between the aperture and the barograph case is otherwise airtight, that the barograph may be placed outside in any convenient position on the machine, that is, on the instrument board. The clockwork which actuates the recording mechanism of the barograph also actuates the rotations of the case and the spring of this mechanism is kept wound up by a small, geared-down propeller of a few inches diameter.

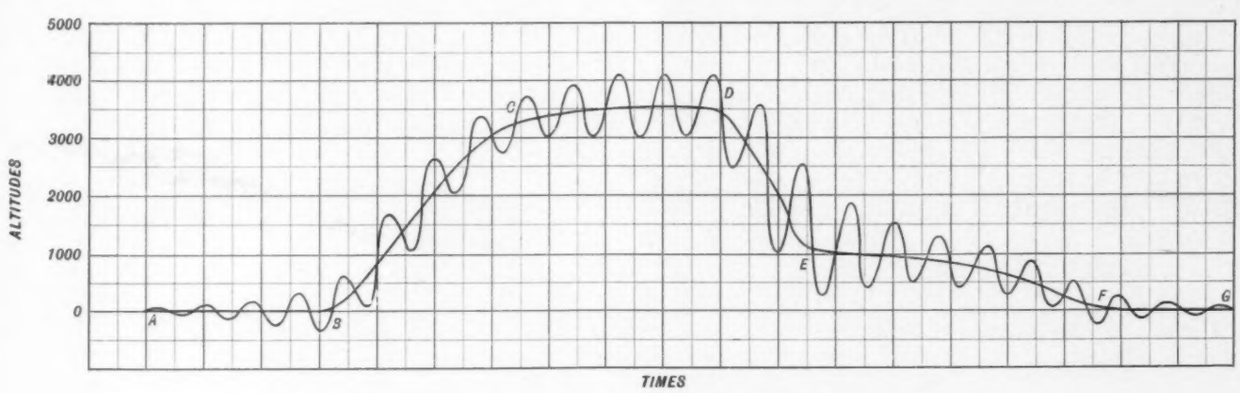


FIG. 5. INDICATIONS OF A BAROGRAPH OF THE NEW TYPE DURING A FLIGHT

Neglecting, for simplicity, the minor variations of the pressure distributions around the instrument case, the record of a

* There is no error introduced by the rotations as shown by wind tunnel tests, even when they are as rapid as ten a second or even more. We are referring, of course, to the pressures in the case and not to the instrument lag.

flight would appear as shown in Fig. 5. Experiments in the wind tunnel show that the reading corresponding to maximum, positive aerodynamic pressure is the same as that due to a standard Pitot tube. Hence the maximum positive amplitudes give the air speeds and no separate air speed meter is required. It follows also, since equal intervals of time are marked off on the graph by the sinuousities of the graph, the slope of their zero line indicates the rate of climb. Such an instrument, therefore, gives in one graph:

(*a*) The true static pressure at all times.
(*b*) The air speed at all times.
(*c*) Rate of climb at all times.

It is, therefore, an ideal instrument for official testing as it can be placed on the machine and sealed, and on the return a complete record of the performance is shown on the one graph.

For example, the graph of Fig. 5 shows a gradual increase of speed at ground level, a climb at slow speed, a leveling out and increase of speed, a dive at high speed, a leveling out and horizontal flight at slow speed, a gradual descent to the ground and final stoppage of the machine.

When the barograph is not placed within the case provided with the rotating aperture this case can be reduced to a very small size. In this event to avoid the difficulty of providing an airtight joint, rotations can be replaced by oscillations alternately through 360 deg.

Notes on Balloon Fabrics

By Junius David Edwards

One essential element of all lighter-than-air craft is a gas envelope. The development of satisfactory materials for the construction of this gas-tight envelope always has been and still remains one of the principal problems in the construction of balloons, and more particularly airships. The object of the present paper is to describe the characteristics of the fabrics now in use, and to indicate the lines along which future development may be expected to take place.

Up to the present time cotton cloth and rubber have formed the basis of practically all fabrics which have been used in this country. The physical characteristics of the cloth must be adapted to the stresses which the envelope is to bear; its weight must be such that the completed fabric will fall within the allowable limits, and the cloth must be of such texture and finish as will lend itself readily to the spreading of a very thin rubber film upon its surface. The cloth is carefully inspected to insure freedom from defects which might lower its strength, and also to remove imperfections in the surface which might leave weak spots in the rubber film.

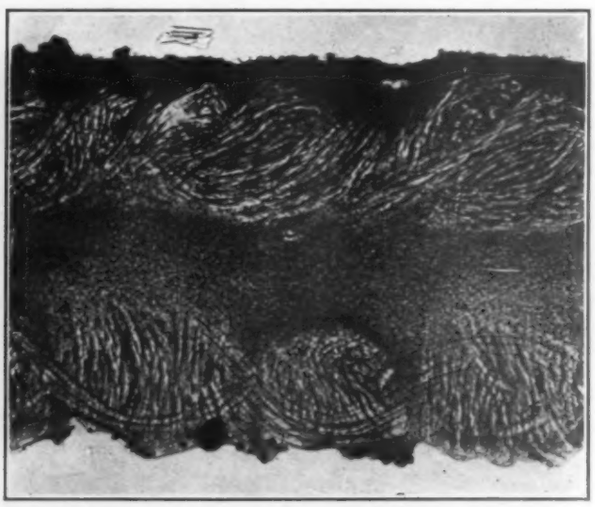


FIG. 1. THIN SECTION OF TWO-PLY BALLOON FABRIC, MAGNIFIED 100 DIAMETERS

The rubber compound is applied to the fabric in the form of a dough by means of a spreader, in which the fabric is drawn between a roll and a knife which scrapes off the excess dough. The rubber compound, which is used for the gas-retaining film, is usually very simple in composition, consisting of gum rubber and sulphur, with litharge, lamp black, paraffin, etc., occasionally added to improve its life or reduce its permeability to gases, as the case may be.

The spreading of the rubber is the most difficult part of the construction process, and it requires experience and skill to secure satisfactory results. The gas-retaining film on the fabric is usually very thin, frequently not over 0.1 mm. in thickness, and yet it may have been applied to the fabric in twenty or more separate coats. This is only one instance of the attention to detail which is necessary in the construction of a satisfactory fabric, and accounts for their high cost.

Single-ply fabrics have only a very limited use at the present time. Two-ply fabrics are used in kite balloons and small airships, while three-ply fabrics are used for large airships. A typical two-ply fabric is shown in cross section in Fig. 1. This thin, transparent section, which is magnified 100 diameters, was cut by means of a microtome, and I am indebted to Miss Bache, of the Bureau of Standards, for preparing and photographing it. The two plies of cloth may be distinguished by the fibers, which show clearly in the illustration. It is common practice to lay one ply on a bias of 45 deg.; this is shown in the section by the variation in angle at which the threads in the warp and filling of each ply are cut. Between the two plies of cloth is seen the main rubber coating or gas-retaining film. On the outside is seen a thin, dark-colored coating of pigmented rubber, which serves to protect the cotton and the rubber from the injurious action of light, heat and moisture. There is also a very thin coating of rubber on the inside of the fabric, which does not show so clearly in the illustration.

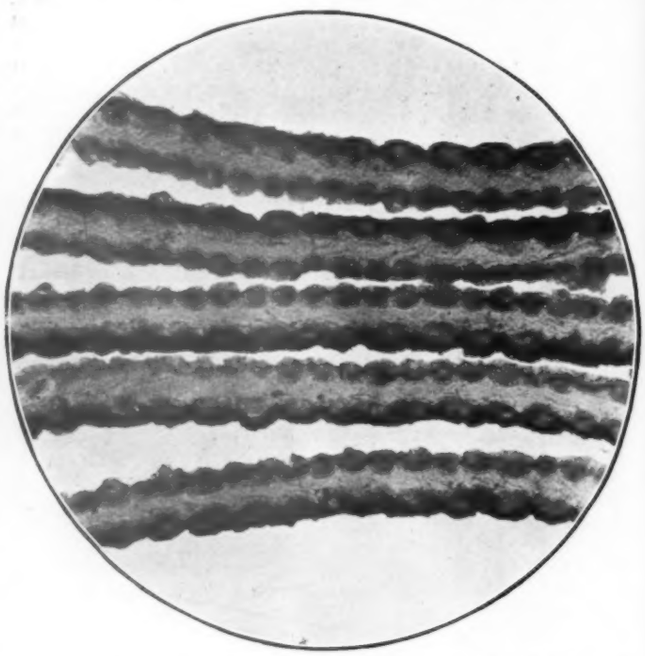


FIG. 2. THIN SECTION OF KITE-BALLOON FABRIC, MAGNIFIED 23 DIAMETERS

A typical kite balloon fabric may be constructed with two plies of 2.5 oz. of cloth and with 3.5 oz. of rubber per sq. yd.

between the plies. A protective coating of 1.0 oz. of rubber is placed on the outside and a coating of 0.5 oz. on the inside. The completed fabric may weigh about 10 oz. per sq. yd. A number of sections of such a fabric are shown in Fig. 2; the magnification in this case is 23 diameters.

Three-ply fabrics are usually made with the middle ply on the bias, and the inside and outside ply straight. The object sought in placing one ply on the bias in any fabric is to prevent, as far as possible, tears or rips in the fabric from spreading. The weights of three-ply fabrics may run as high as 16 or 18 oz. per sq. yd. The envelopes of the multiple-engined airships which the Navy has been building lately are made from three-ply fabric.

Rubber is not the ideal substance for use in making "gas-tight" fabrics, because rubber is far from being impermeable to gases. Because of the solubility of gases in rubber, a rubber film, no matter how perfect in the sense of being free from pin-holes or porosity, would still be permeable to gas. In a balloon, the hydrogen in contact with the inner surface dissolves in the rubber, penetrates to the outer surface, and there evaporates into the surrounding atmosphere. In the same manner, but at only about one-quarter the rate, air penetrates in the opposite direction into the balloon. These facts are of great importance in considering the gas-holding properties of a fabric. Neither the loss of hydrogen nor the contamination of the gas in the envelope are so important with a good kite balloon. They are of considerable importance, however, in the case of airships where continuity of service is desired and where it is a costly proposition to reinflate the envelope.

The development of a supply of helium has introduced another factor which is bound to have a profound influence on the development of balloon fabrics. Helium is far too scarce and costly to waste, and the gas in a ship's envelope must be conserved as far as possible. Rubber is permeable to helium, as well as to hydrogen, although it penetrates at a somewhat slower rate. The permeability of the rubberized fabric may be reduced somewhat by coating with cellulose acetate or nitrate dope; but the improvement is not lasting, and the dope sometimes has an injurious effect on the fabric. Coating the inside of the fabric with goldbeaters' skin is an expedient which the British have tried. Goldbeaters' skin has a very low permeability; it can be fabricated into large sheets which have a permeability to hydrogen of only 0.5 to 1.0 liter per sq, m. per 24 hr. The best rubberized fabrics seldom have a permeability (at 25 deg. Cent.) much below 10 liters per sq. m. per 24 hr. Although goldbeaters' skin has been successfully used in airships of the rigid type, a satisfactory fabric made with goldbeaters' skin has not yet been realized for non-rigid ships.

If the helium project is to receive the support and development which has been announced, then it seems equally important that a well-planned and concerted effort should be made to develop a gas-holding fabric which shall satisfactorily conserve the helium. It would be unscientific, as well as foolish, to say that goldbeaters' skin is the best which can be done in the line of a gas-tight fabric. Adequately supported, with a carefully selected personnel, and with the proper facilities, as, for example, the Bureau of Standards affords, such a research would be highly profitable, not only in insuring the successful application of helium, but to the balloon fabric art in general.

Another detail of fabric construction in which there is room for considerable advancement is the protection from deterioration. Light, heat and moisture have an injurious effect on both cotton and rubber, and it is necessary, therefore, to add an outer protective coating to the fabric. Pigmented rubber has long been used for this purpose, but the aluminum-coated fabrics developed in the last few years in England and America are, generally speaking, the most durable fabrics made. The aluminum powder is spread or printed on the fabric in the form of a thin rubber cement. It forms a highly reflecting and relatively durable coating, which remains fairly cool and protects the cloth and rubber underneath in a satisfactory manner. All fabrics for Navy airships and kites are now constructed with an outer aluminum coating.

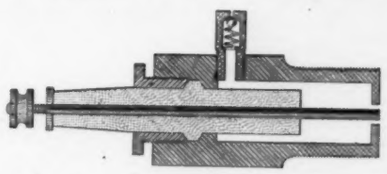
The question of the radiation properties of the fabric is one to which too little attention has been paid hitherto. The importance of this subject may be appreciated from the fact that the character and color of the fabric may make a difference of as much as 40 deg. Fahr. in its temperature when exposed to sunlight. It is important to keep the fabric as cool as possible because the permeability increases rapidly with increase of temperature, and the deterioration of the rubber is accelerated. Furthermore, rapid changes in the temperature of the gas envelope cause corresponding fluctuations in the buoyancy of the balloon.

These few notes illustrate the multiplicity of problems involved in the development of a satisfactory balloon fabric, and indicate some lines along which great improvement can reasonably be expected as a result of intelligent research.

Ventilated Spark Plug

In aircraft engines it is especially important that the spark plug should be thoroughly protected from fouling, and it is also highly desirable that the plug should have some means of cooling.

Protection from fouling is as a rule provided by means of baffles at the terminal end of the plug, while fins are provided on the body of the plug to secure cooling. It is obvious, however, that such an arrangement makes the plug cumbersome and expensive; moreover, the baffles, while protecting the plug from fouling, materially reduce the chances of the central terminal being well cooled.



DIAGRAMMATIC CROSS-SECTION OF THE NORTHWIND PLUG

To overcome these drawbacks, an entirely novel design of a spark plug has just been placed on the market by the Cammen Laboratories, 42 West 39th Street, New York, under the name of the Northwind plug. In construction, the new plug recalls a priming plug, with the difference, however, that instead of the priming cup, a little ball check air valve is provided. In addition to this the usual side wire electrode is replaced by a washer with a hole, through which passes the center electrode.

During suction stroke the atmospheric pressure forces the ball back and air is admitted to the inner chamber of the plug. This cools the porcelain and the central electrode blows out any oil that may have reached the electrodes and prevents carbon formation on the plug. As soon as the compression stroke begins, the ball is forced back against its seat and leaks past it are practically impossible.

It is believed that the use of ventilated plugs will materially assist in reducing preignition and other forms of engine trouble.

New York-Chicago Air Mail

A continuous air mail service between New York and Chicago was inaugurated by the Post Office Department on July 1. The route is divided into three legs, the intermediate stations being Bellefonte, Pa., and Cleveland, O. The Cleveland-Chicago leg has been in operation since May 15, but the organization of the other two legs was delayed on account of the difficult ground the route follows, particularly between Bellefonte and New York, where few natural landing grounds are available. The total distance is about 750 mi.

With the new through-going air mail service letters from New York to Chicago will reach their destination in from eight to nine hours, while the delivery of mail for the Pacific Coast will be advanced about twenty-four hours.

Most of the machines used on this route are remodelled DH-4A biplanes with Liberty-12 engines and a capacity of 400 lb. of mail.

The New York terminal of the air mail service has been transferred from Belmont Park to Newark, N. J. This arrangement was made to avoid the fog which hangs over Long Island in the early morning hours and also in view of better train connections with New York.

Electric Arc Welding in Aircraft Construction

By R. E. Kinkead

Engineer, Welding Dept., Lincoln Electric Co.

The application of electric arc welded joints to aircraft construction on any considerable scale is within the range of future possiblity, but offers little promise of success as applied to the materials used in construction at the present time. It is a process or means of fastening pieces of metal together which the designer of aircraft should certainly understand and keep in mind as the evolution of types proceeds, so that when the opportune moment arrives its advantages may be utilized.

At the present stage of development of welding, with the heat of an electric arc, it may be said to be an economical means of fastening together parts made of mild steel or soft iron. Copper, certain bronzes and certain alloy steels may be welded successfully, but the field is just being explored in these directions and much remains to be done before it would be safe to use such a joint in aircraft production as a standard factory production process.

Mild steel may be successfully welded and the process used in factory production with the assurance that predetermined results will be obtained. Wherever mild steel is now used in airplane or airship construction, it may be welded with safety; in fact, in many joints, welded construction offers a greater degree of safety than it is possible to secure with bolted to riveted construction.

However, in strength members which are welded, it would be necessary to actually test each welded joint for perfect safety since it is not possible to determine by inspection alone whether or not the welded joint is perfect after it has been made. Inspection while the joint is being made may be relied upon, but that is impractical as a factory process. Since it is practical to make welded joints which are stronger than any of the original sections, the test might be made up to 80 per cent of the elastic limit of the weakest member of the joint. The fact that the welded joint may be stronger than a riveted, bolted or screw joint offers pleasing possibilities in the matter of reducing the weight of a structure of mild steel, since the weakness of such structures, due to this inherent defect of the type of joint, must be compensated by the use of heavier essential members.

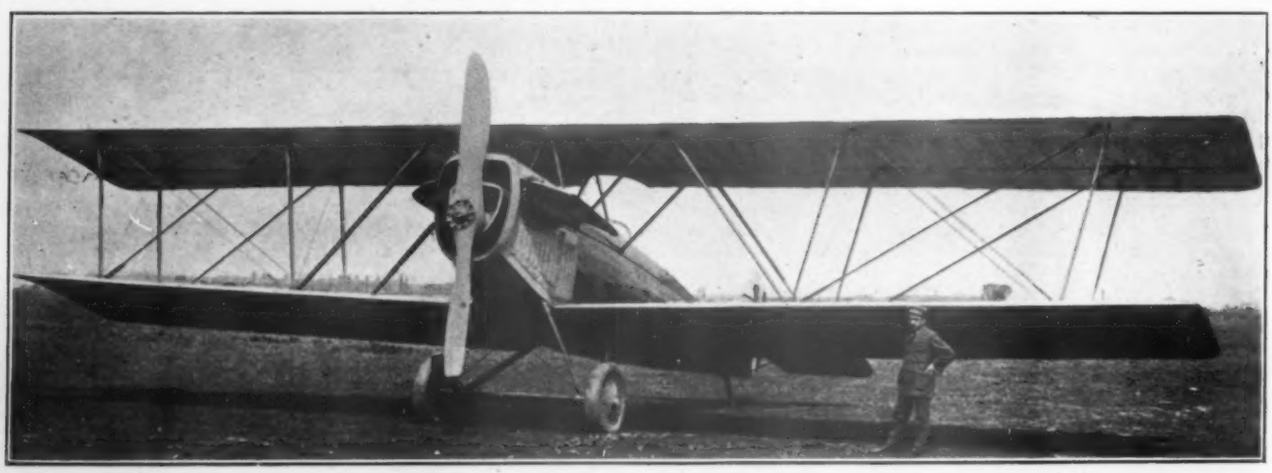
Welding of steel alloys with the electric arc is difficult to make successfully for two reasons. Alloy steels are practically all exceedingly "wild" at high temperatures, making it difficult to accomplish complete fusion in the joint. The second difficulty arises from the fact that practically all alloy steels harden when rapidly cooled, and since the heat of the arc is extremely localized, the mass of metal surrounding the joint cools the metal in and adjacent to the weld to such a degree that the utility of the joint is seriously affected. Heat treatment would eliminate the second source of trouble if it were practical, but it is extremely improbable that heat treatment of the light structures used in aircraft construction would be practicable.

It is virtually impossible to weld aluminum with the electric arc. No practical method has been devised for eliminating the oxide from the molten metal while it is in the arc. Another difficulty arises owing to the high temperature of the arc, which must be maintained without reduction as long as the arc is in operation, although this high temperature makes it impossible to control the molten metal. Aluminum changes from solid to molten state without change of external appearance in the high temperature of the arc, so that it is quite impossible to exercise sufficient control over it, except in a mold, to make a reliable joint. So far the aluminum-copper and other aluminum alloys have presented the same obstacles to successful welding.

The possibilities of using an alloy which can be successfully welded, in addition to possessing the requisite properties of high tensile strength and lightness, are for the most part unexplored. The welded joint is the logical fastening for any structure where saving of weight is of great importance because the welded joint may be made stronger than any other kind of fastening.

The Fiat BR Long-range Bomber

The Fiat BR biplane was designed just before the close of the war for use as a high-speed long-range bomber. The span is 51 ft. 9 in., the chord 7 ft. 9 in., and the overall length



32 ft. The power plant consists of a 12-cyl. Fiat engine developing 700 hp. and driving a tractor screw of 11 ft. 3 in. diameter. The exhaust pipes, which project from each side of the fuselage, are encased with sheet metal so as to form a supplementary bearing surface. The struts and wires are all streamlined. The net weight of the machine is 2¼ tons, and the useful load 1½ tons.

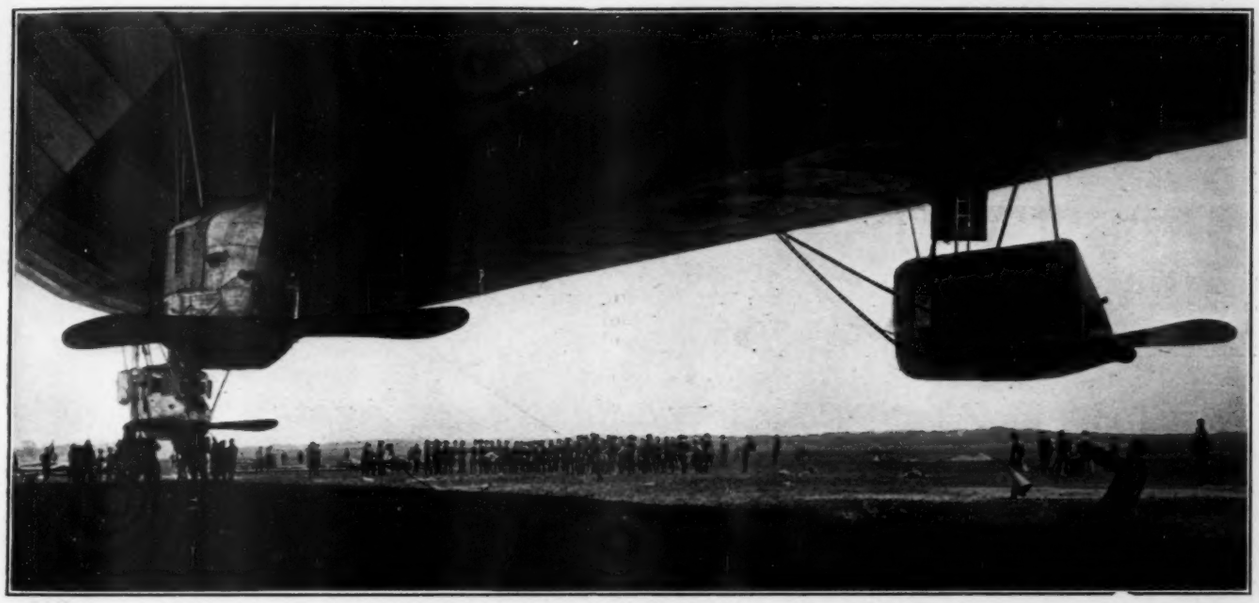
In official tests a high speed of 158 m.p.h. was developed, but this has since been increased in private tests to 163 m.p.h., and a world's altitude record was established by climbing 23,768 ft. in 24 min. with three occupants aboard. The officially timed climbing speed is 1,000 m. in 3 min. 45 sec.; 2,000 m. in 7 min. 30 sec.; 3,000 m. in 12 min. 30 sec.; 4,000 m. in 18 min. 16 sec.; and 5,000 m. in 27 min.

The Fiat Co. of Turin have now under construction an airplane designed on the same general lines as the type BR, which is to have a speed of 150 m.p.h., and is intended for a trans-Atlantic flight. Mr. Brack-Papa, test pilot for the firm, has been picked for the projected flight across the Atlantic.

British Airship R-34 Described

The British airship R-34, Maj. G. H. Scott, R. A. F., commander, completed on July 5 the first westward crossing of the Atlantic, landing at Roosevelt Field, Mineola, L. I., N. Y., 108 hr. 12 min. after she left East Fortune air station, near Edinburgh, Scotland. According to the official log made public by Brig.-Gen. E. M. Maitland, R. A. F., official observer for the British Air Ministry on board the R-34, the air distances covered were as follows: East Fortune to Trinity Bay, N. F., 2,050 naut. mi. (2,357.5 sta. mi.); Trinity Bay to Roosevelt Field, 1,080 naut. mi. (1,242 sta. mi.), that is, a total distance of 3,130 naut. mi. (3,559.5 sta. mi.). This is not counting the distance the airship drifted off her course at various times under the powerful winds encountered.

When the R-34 took off at East Fortune the wind was favorable for the crossing, but this condition quickly changed and the airship soon encountered strong head winds which she had to fight all the way to Newfoundland, sighted 59 hr. after the start. During that time the airship flew at altitudes ranging from 400 to 7,000 ft. Over Newfoundland the R-34 ran into a heavy depression, with winds blowing 50 m.p.h. and a thunderstorm which violently rocked the ship and once lifted her up 800 ft. On shaping her course down the coast the R-34 ran into another thunderstorm and strong head winds continued to blow; by then the gasoline supply was getting low and the commander considered the advisability of making Boston and sent out radio calls for assistance. Shortly after this, however, the wind veered in favor of the ship and enabled the R-34 to complete the flight unassisted. On reaching Roosevelt Field Major Pritchard, executive officer of the R-34, stepped down by parachute from an altitude of 2,000 ft. to superintend the landing arrangements. The R-34 was then moored to a concrete anchorage, while the grab ropes were manned by a handling party furnished by balloon detachments of the United States Army Air Service, commanded by officers of the Naval Air Service.



THREE-QUARTER REAR VIEW OF THE FORWARD GONDOLA AND WING CARS OF THE R-34
Photo Edwin Lewick.

The complement of the R-34 was made up as follows:

Ship's Officers—Maj. G. H. Scott, captain; Capt. G. S. Greenland, first officer; Sec. Lieut. H. F. Luck, second officer; Sec. Lieut. J. D. Shotter, engineer officer; Brig.-Gen. E. M. Maitland, observer for the Air Ministry; Maj. J. E. M. Pritchard, executive officer; Lieut.-Comdr. Z. Landsdowne, U. S. N.; Maj. G. G. H. Cooke, navigating officer; Lieut. Guy Harris, meteorological officer; Sec. Lieut. R. D. Durrant, wireless officer; W. O. W. R. Mayes, coxswain.

Warrant Officers and Men—Engineers, Flight Sergts. Gent, Scull and Riplee, Sergts. Evenden and Thirlwall, Corporals Cross and Gray, Air Craftsmen Graham, Parker and Northeast and L. A. C. Mort.

Riggers—Flight Sergt. Robinson, Sergt. Watson, Corpls. Burgess and Smith, L. A. C. Forteath and L. A. C. Browdie.

Wireless Telegraphy Operators—Corpl. Powell and A. C. Edwards.

In addition to the above, Rigger W. Ballantyne, a former member of the crew, shipped as a stowaway.

Constructional Details

The R-34 was built to the designs of the British Admiralty by Wm. Beardmore and Co., Ltd., of Glasgow; the machinery was built and installed by the Sunbeam Motor Car Co., Ltd., Ltd., of Wolverhampton. The R-34 was launched on March 14, 1919, at the Inchinnan aerodrome, where she was built, and during her first trial flight remained 21 hr. in the air because fog prevented her landing at East Fortune aerodrome whither she was bound. On June 14 the R-34 made another 20-hr. cruise for the purpose of testing the range and working of her wireless. During this trip the airship talked with the Azores, a distance of 800 m.

The general characteristics of the R-34 are as follows: Capacity, 2,000,000 cu. ft. Number of gas bags, 19. Overall length, 650 ft. Master diameter, 80 ft. Overall height, 92 ft. Gross lift, filled with hydrogen of 95 per cent purity, at 15 deg. Cent. and 760 mm. barometric pressure, 68 tons. Disposable lift, 25 tons. Total horsepower, 1375. Full speed, 75 m.p.h. Ceiling, 14,000 ft.

Hull and Cars

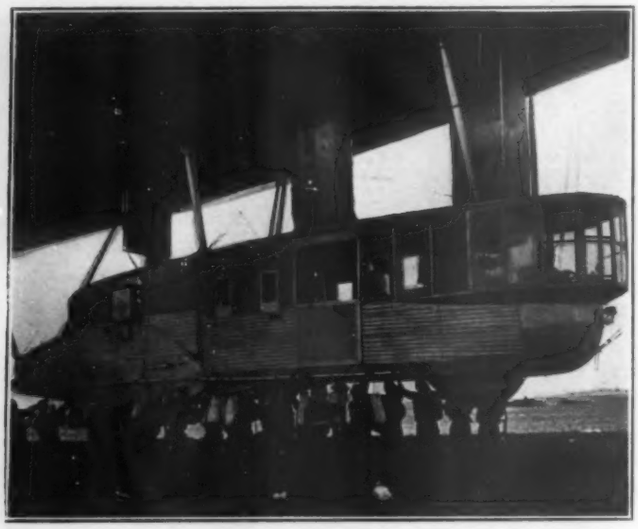
The R-34 is a rigid airship of the Zeppelin type. The framework of the hull consists essentially of longitudinal and transverse lattice girders of duralumin which are built up of three corner rails and X-shaped web pieces; these girders cross one another at right angles and the bays thus formed are trussed with wire stays.

In the bottom of the hull a triangular A-shaped keel runs from end to end of the ship and affords passage between the cars, also providing access by means of vertical ladders to the platforms on top of the hull. In this keel are situated eighty-one gasoline tanks of 71 gal. capacity each, as well as storing arrangements for lubricating oil for the engines, water ballast, food and drinking water, and living quarters for officers and men. The sleeping arrangements consist of a hammock for each of the men off watch, suspended from the main ridge girder of the keel.

The weights distributed in the keel during the transatlantic flight were apportioned as follows:

	Tons
Gasoline (4,900 gal.)	15.8
Oil	0.9
Water ballast	3.0
Crew and baggage	4.0
Spares	0.2
Drinking water	0.42
Total	24.32

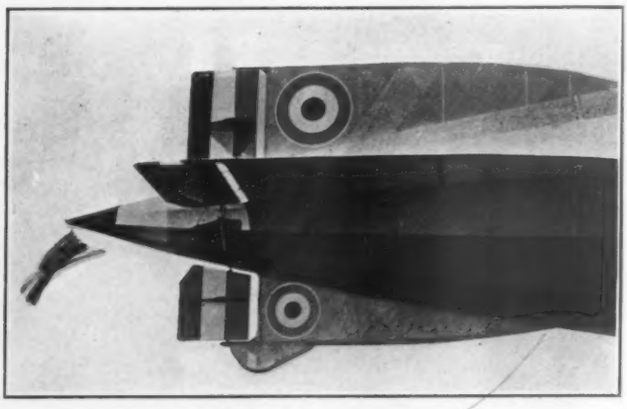
Athwartship the hull is braced by radial wire trusses, which occur at the transverse frames; these form the partions which



FORWARD GONDOLA OF THE R-34
Photo Edwin Lewick.

separate the nineteen gas bags from one another. The gas bags are made of balloon fabric lined with goldbeater's skin, which is the most gas impervious fabric known. The outer cover is of doped water proof fabric and is laced onto the hull in sections.

The tail planes consist of horizontal and vertical fins, with hinged flaps for elevating and steering, and are trussed to



STERN OF THE R-34
Photo Edwin Lewick.

the hull by wire stays. The framework of the tail planes is built up of lattice girders in the fashion of the hull.

Four cars are suspended from the hull on stout stream lined struts. The forward gondola, which is the largest of all, is subdivided into (1) the navigating room, (2) the radio cabin, and (3) the forward engine room, in which is fitted a Sunbeam Maori-4 engine. The navigating room contains the elevating and steering wheels as well as all the navigating instruments, including gas pressure gauges, gas thermometers and level indicators, and also the engine telegraphs. Amidships two wing cars of much smaller proportions are fitted; these serve as engine rooms only, and so does the after gondola. But while the wing cars are each equipped with one Sunbeam Maori-4 engine only, and drive (like the forward engine) 16-ft. propellers, the after gondola, which is much larger than the wing cars, is fitted with two Sunbeam Maori-4 engines arranged tandem wise and with a 19½ ft. propeller which suitable clutches allow to be driven by either or both engines. All propellers are provided with a locking device which holds them in horizontal position when the engines are stopped and protects them against possible injury from the ground.

The Machinery

The machinery of the R-34, which was manufactured and installed by the Sunbeam Motor Car Co., comprises in addition to the five engines the clutches, intermediate shafts, reduction gear, propeller shafts and propellers, together with the piping, radiators, oil and water tanks, etc. The Sunbeam Maori-4 engines, which have been specially designed for airship use, have 12 cylinders in two rows of six each, set in V-form at an angle of 60 deg. The cylinders are of 110 mm. bore and 135 mm. stroke, each having four overhead valves which are actuated by two camshafts to each row of cylinders, the camshaft drive being by a train of gears. The articulated system is adopted for the connecting rods and a flywheel is fitted to the crankshaft.

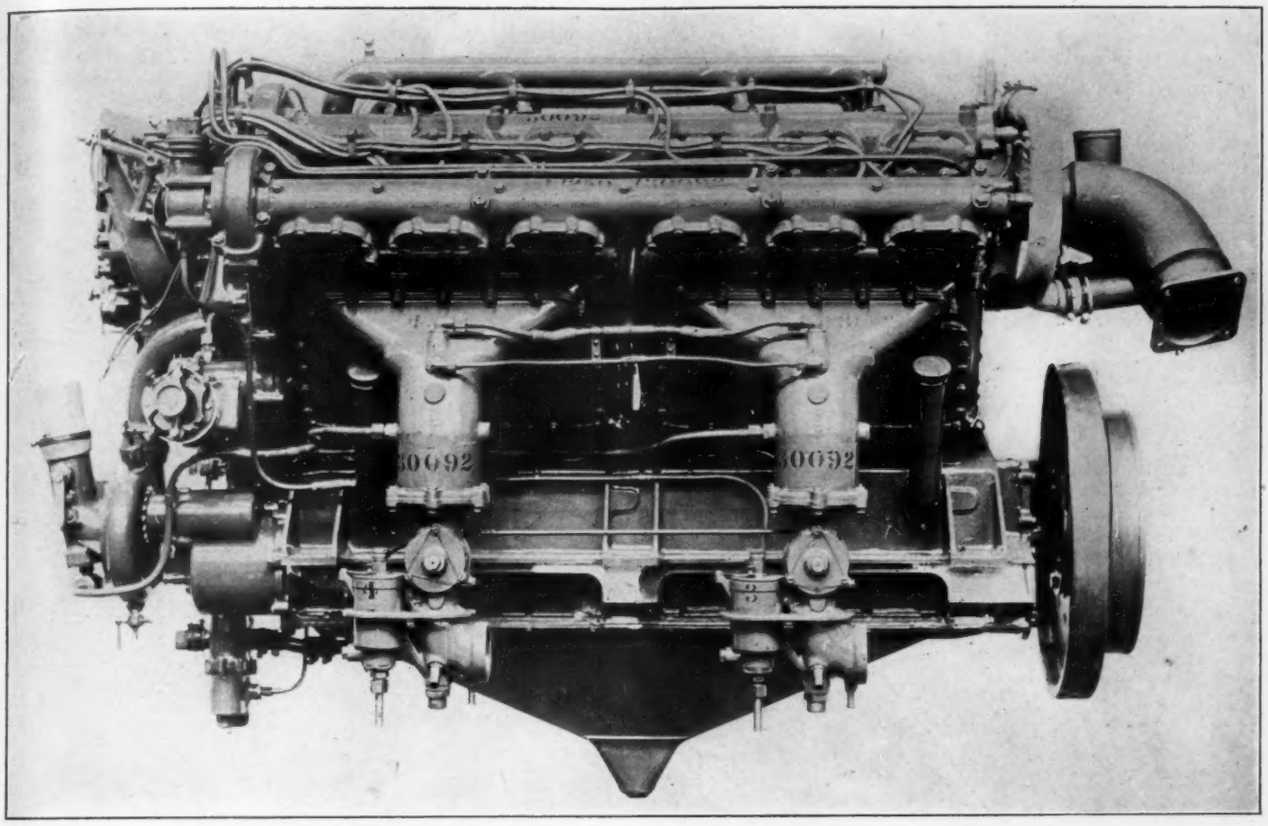
These engines are designed to run at 2100 r.p.m., the b.hp. at this speed being 275. The carburetors, of which there are

REAR VIEW OF THE AFTER GONDOLA OF THE R-34, SHOWING 19½-FT. PROPELLER
Photo Edwin Lewick.

four, are of the Claudel Hobson B.Z.S. 38 type, and are fitted outside the V, gasoline being fed to them either by gravity or by pressure. The ignition is by two 12-cyl. magnetos. The water pump is of specially large dimensions and a governor is fitted so that when the engine speed reaches 2500 r.p.m., or when the oil pressure falls below 20 lb. per sq. in., the ignition is cut off. A hand starter and compressed air starter are provided. The exhaust pipes are provided with a special arrangement for cooling by water.

The above mentioned flywheel carries one element of a friction clutch. This element is driven from the flywheel by means of a series of composite leather and brass driving pieces which are interposed to equalize the stresses on the teeth of the main wheels. The clutch itself is of the multiple disc type with a single central spring and contains a series of ten phosphor bronze plates of special alloy making frictional contact with ten similar plates of steel. The central spring is operated by a lever on the control station in connection with the engine through a pair of collars fitted with an eccentric link in such a way that the pressure of the spring is balanced when driving, and the end load on the crankshaft is reduced to a minimum when declutching. From the clutch the power is led by means of an intermediate shaft, fitted with a dog coupling for permanent disengagement when necessary, to a gear box fitted to the after end of each gondola and wing car.

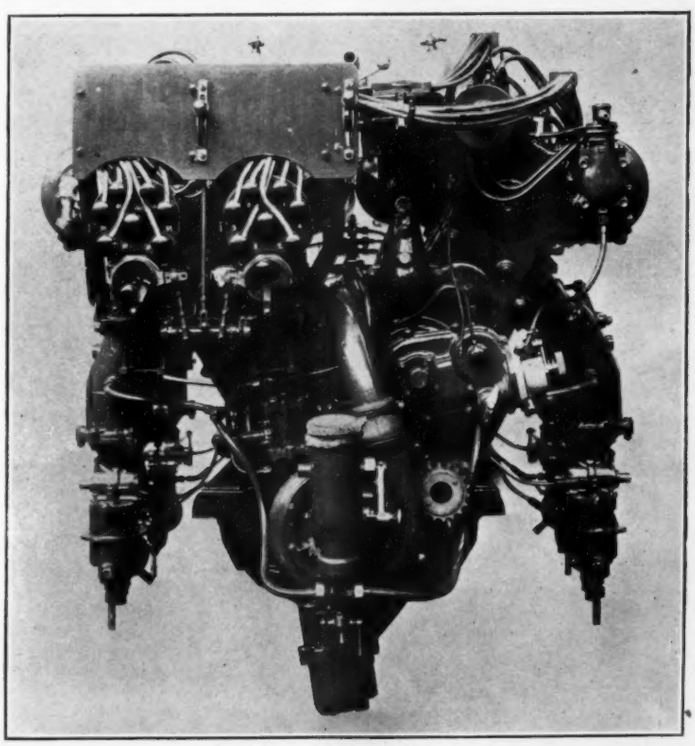
The gear boxes are of three types. In the forward gondola



INDUCTION SIDE OF THE SUNBEAM MAORI-4 ENGINE

the gear box is a plain reduction type without reverse gear, reducing the speed from the crankshaft revolutions of 2100 to 540 per min. The second gear box is of reversing type and is used on the wing cars, and gives similar reduction, but allows by means of sliding gears for the direction of rotation of the propeller to be changed for maneuvering purposes. The third gear box is a special reduction type, in which two pinions are used, both engaging with one common spur wheel attached to the propeller. This is fitted to the after gondola, which carries two engines. All gear boxes are of similar detail design, the gear wheels being of large diameter, case hardened, and fitted with pumps so arranged as to ensure a constant supply of lubrication to the teeth and bearings, etc. Small tanks are supplied containing the supply of oil for the gear boxes, and are fitted to the cars near the gear boxes.

The radiators are coupled by aluminum piping to the engines and to an aluminum tank arranged in the hull of the ship. These tanks were also supplied by the Sunbeam Co. Special provision is made to enable the effective cooling area of the radiator to be adjusted to suit the temperature of the surrounding air and the speed of the engines. This is effected by means of a hoist which permits to regulate the height of the radiator above the cars. Branch pipes are supplied for heating when on the ground and supplying cold water for stationary trials. The gasoline services fitted by the builders of the ships were connected by the Sunbeam Co. to filters and gasoline cocks on the gondolas, the filters, etc., being duplicated so as to enable them to be cleaned while the machinery is in motion.



MAGNETO END VIEW

In addition to the usual lubrication fittings supplied with the engine special oil cooling tanks placed outside the gondolas are fitted. These communicate with the oil circuit on the engines through a series of connections made with oil cocks fitted with indicating plates, so that the amount of oil passing the coolers can be adjusted to suit the running and temperature conditions, and a fresh supply added to the oil in circulation from a

tank situated in the main structure of the ship. The oil circuit also incorporates a special filter so arranged that one-half of the filter is continually in use while the other half is taken apart for cleaning purposes.

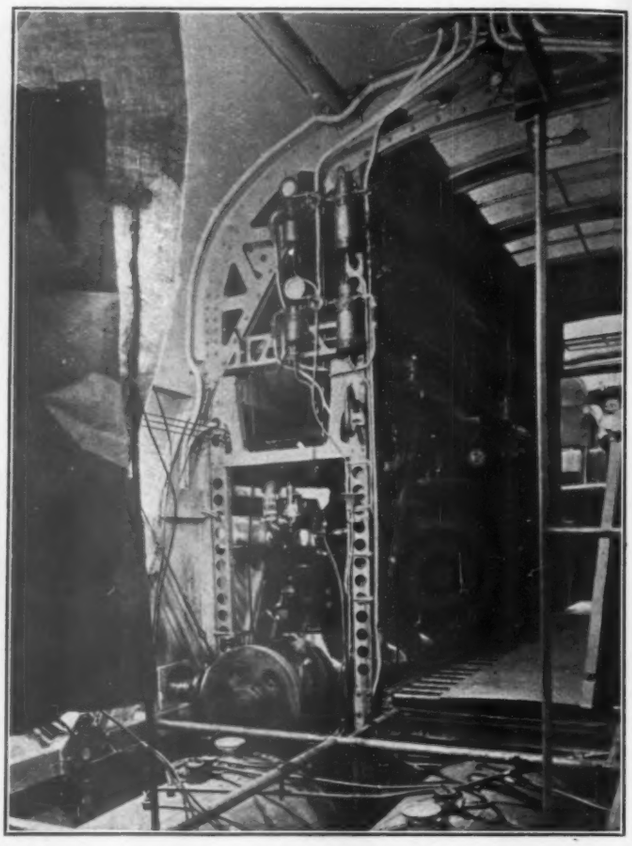
Wireless Equipment

The wireless equipment of the R-34 consists of a main transmitting set of 1,200 mi. range, which is of the continuous type, an auxiliary continuous wave set, spark set, a wireless telephone with a range of 100 mi., and a wireless direction finder of 300 mi. range. A 400-ft. trailing aerial is used for all these sets except for the direction finder. The latter as well as all the rest of the wireless equipment functioned excellently and assured continuous communication with the Air Ministry in London throughout the cruise, while the Cape Race station read the small spark set at a distance of 300 mi., despite the fact that it is only 1/10 of an electric horsepower.

Giant D. F. W. Biplane

The accompanying photographs illustrate one of the latest German giant machines, a D. F. W. biplane driven by four 6-cyl. water-cooled engines of 250 hp. each.

All four engines are housed in the fuselage and transmit their power by means of long bevel gear shafts to four propellers. Two of these are tractors and are mounted below the upper plane, while the two pushers are mounted on the lower plane. The driving shafts for the tractor screws run diagonally up and out from the upper engines—the four engines being fitted in pairs on either side of the fuselage and on top of one another—while the shafts for the pusher screws extend horizontally from the lower engines. It seems likely that the pusher screws are not influenced by the slip stream of the tractors; it will however be noted that the line of thrust of the tractors is well above the center of gravity, while that of the pushers is well below. What influence the simultaneous shutting off of either the tractors or the pushers may exert on the longitudinal stability of the machine is a fair object for speculation.



The two tractor screws revolve in one direction, and the pushers in the opposite.

The arrangement of the ten-wheel landing gear is noteworthy, as is the biplane tail, with balanced elevators and rudders. The fuselage is apparently of monocoque construction, except the forward portion in which a considerable amount of metal seems to be used. No information is at hand as to the general dimensions of this machine or as to its degree of success.

The manufacturers of the D. F. W. airplanes are the Deutsche Flugzeug Werke (German Airplane Works), of Leipzig, Saxony.

Course in Aerodynamics and Airplane Design

Part III.—Experimental Aeronautical Engineering

By Alexander Klemin

Technical Editor, Aviation and Aeronautical Engineering; Consulting Engineer, Aerial Mail Service; Consulting Aeronautical Engineer

(Copyright, 1919, by Alexander Klemin)

Section 6. Instruments for Full Flight Testing—*Continued*

Standard Aneroid Barometer

Fig. 12 shows a standard aneroid barometer with the cover removed. The mechanism of this instrument is practically the same as that in the altimeter used in airplanes. The corrugated expansion chamber *M*, from which the air has been exhausted, expands or contracts with changes in atmospheric

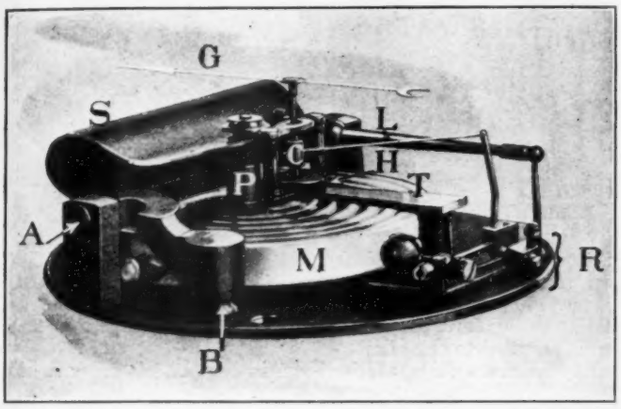


FIG. 12. STANDARD TYPE OF ANEROID BAROMETER, WITH COVER REMOVED

pressure, and is regulated by the leaf spring *S*. The latter is mounted on pivots *A* and fitted with a compensator *B* to equalize, to some extent, the expansion of the upper and lower sections of the leaf spring *S*. As the expansion chamber *M*

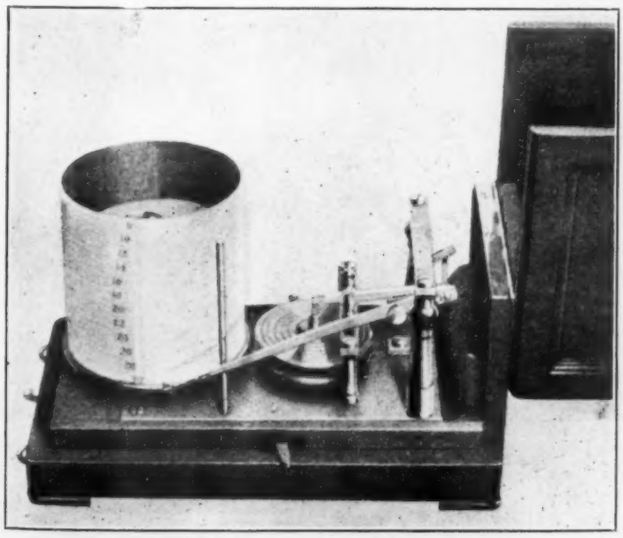


FIG. 13. STANDARD TYPE OF FRENCH BAROGRAPH

expands or contracts, its motion is transmitted through the spring *S* to the lever *L*, which is connected to the opposite end of the leaf spring. This is connected by a system of small levers *R* and a very fine chain to the drum *C* on the spindle of the indicating pointer *G*. An enclosed hair spring *H* tends to turn the pointer in the opposite direction to the chain, and thus keeps the chain under a very light tension all the time. This small chain occasionally may cause trouble by kinking or breaking where it winds on the drum *C*. A dial (not shown in the illustration) is mounted under the pointer *G*. This dial may be marked to indicate atmospheric pressure, altitude, or to predict weather changes.

To calibrate the altimeter, it is placed in a metal pan which is connected to a mercury column gage. The pan has a heavy

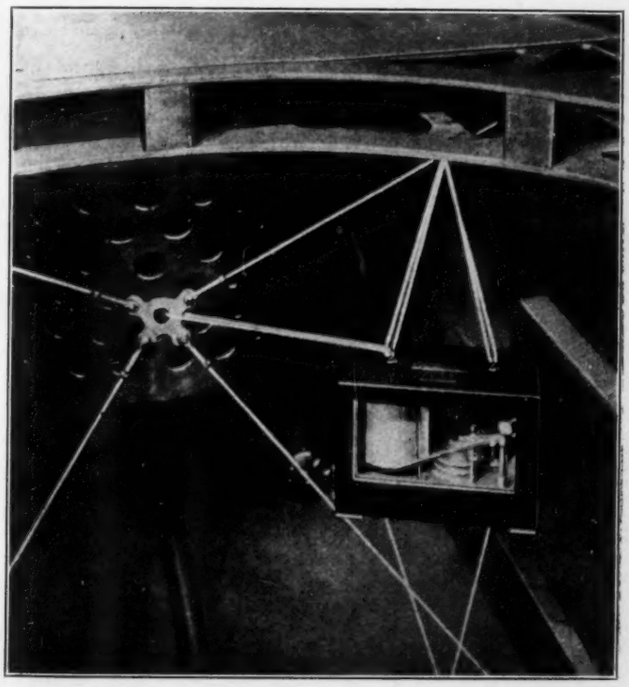


FIG. 14. BAROGRAPH SUSPENDED IN A FUSELAGE

glass covering resting on a rubber gasket. The pressure is decreased by regular intervals at a temperature of 10 deg. Cent., and simultaneous readings of the mercury gage are taken. This is continued until the greatest height of the instrument has been reached. The pressure is then increased until the ground pressure is reached.

The height corresponding to the observed height of the mercury is computed from the formula $H = 62900 \log_{10} \frac{P_o}{P}$ based on a temperature of 10 deg. Cent. To determine whether the instrument is affected by temperature, the above test is repeated at temperatures of —10 deg. Cent. and + 40 deg. Cent.

Barographs

There is very little difference between the barograph and the altimeter—in fact, the barograph is merely a recording altimeter. Instead of the pointer and dial of the altimeter, there is a pen on the barograph which marks the altitude on a chart wound around a drum. The drum is revolved by clockwork, and the pen draws an actual curve of altitude against

time on the chart. Owing to the sudden shocks encountered in landing and starting these instruments are suspended by elastic cords which absorb the shocks. A well-known and widely used barograph is shown in Fig. 13, and a method of suspension in Fig. 14.

In applying the chart to the drum, it is necessary to have the right-hand edge overlap the left so that if the length of the flight makes it necessary, the pen can continue its motion beyond one complete revolution. The right edge of the paper is covered by a flexible metal blade which is clamped into place.

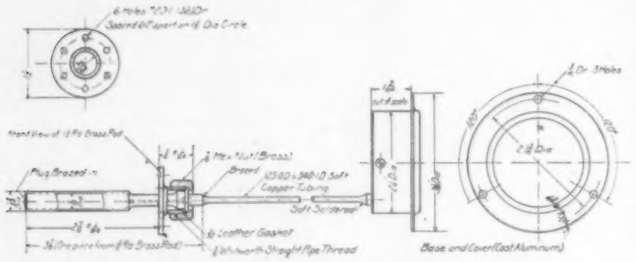


FIG. 15. TWO-FLUSH INDICATING THERMOMETER

The cylinder should be revolved by hand to make sure that the pen will not catch on the clamp.

The pen of this type of instrument should be so adjusted that it just touches the chart; this will give a clear and accurate record of the climb. If the pen is pressed heavily against the surface of the chart, the results will be blurred and accurate interpretation will be impossible. Ordinary ink cannot be used for this purpose, as it is spilled too easily and dries out

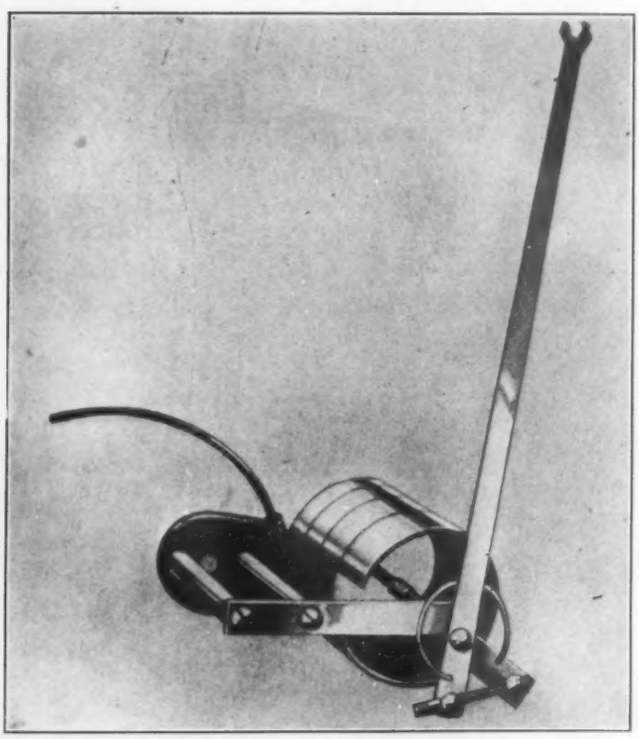


FIG. 16. MECHANISM OF THE FOXBORO THERMOMETER GAUGE

too quickly, thus caking the pen. The ink used is a special ink, viscous and slow-drying.

Just before starting, the clockwork is wound up and the cylinder revolved by hand so as to bring the metal blade a little to the left of the pen, and then the pen is applied to the chart.

Recording and Direct Reading Thermometers

These instruments are used for recording water and strut temperatures, and their construction is very simple. A bulb, such as is shown in Fig. 15, is filled with a liquid of high vapor pressure such as sulphur dioxide or methylehloride. Under varying temperature and the consequent variations in

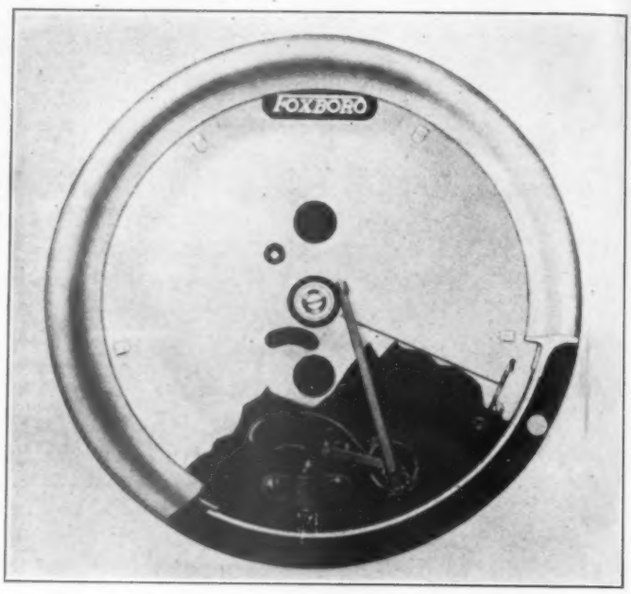


FIG. 17. FOXBORO RECORDING THERMOMETER GAUGE

pressure, the gage shown in Figs. 16 and 17 is actuated. The gage consists of a comparatively long helical tube mounted to a base. The free end of the tube is securely fastened to a shaft running through the center, and the arm that holds the pen is fastened to this shaft.

A typical recording face is shown in Fig. 18. There are, of

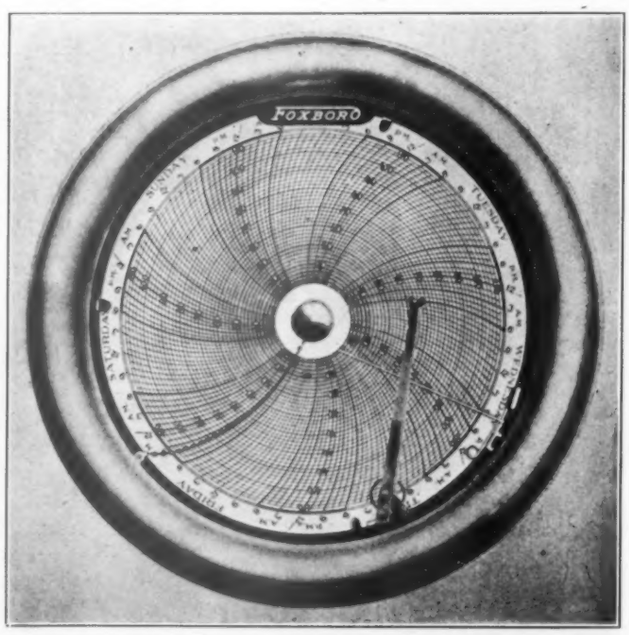


FIG. 18. FACE OF TYPICAL RECORDING THERMOMETER

course, many variations in tube sizes and clockwork arrangements. The gage dials usually run from 0 deg. to 100 deg. Cent., or from 40 deg. to 100 deg Cent., or corresponding scales in Fahrenheit degrees.

Tachometers

The airplane tachometer must be light, small, rugged and entirely self-contained. It has most difficult conditions to meet, such as violent accelerations, shocks, high and low temperatures and rapid changes in air density. For this reason

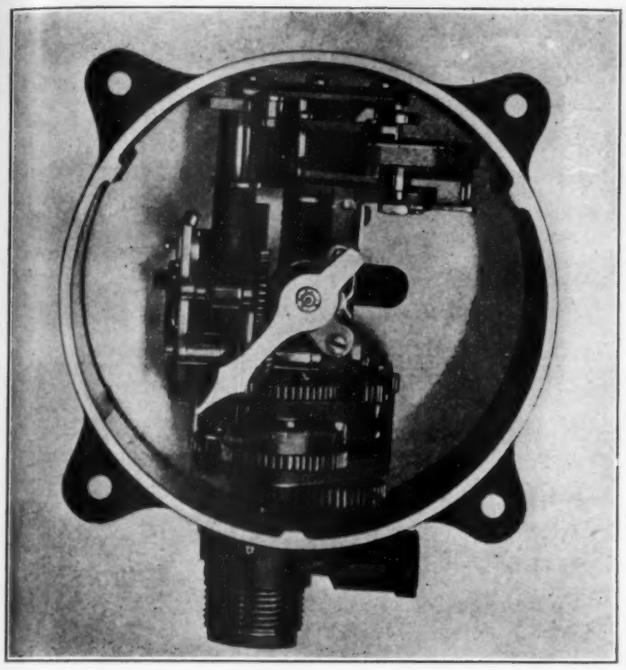


FIG. 19. TEL CHRONOMETRIC TACHOMETER

certain types of automobile speedometers are quite unsatisfactory for use in the air.

In ordinary flying, consistency is more important than accuracy, since the tachometer is then used as a danger signal, but in performance tests, accuracy is absolutely essential to the determination of results which will make possible comparisons of value.

The tachometers in most common use are of two types—chronometric and centrifugal. A Tel chronometric tachometer is shown in Fig. 19, and a centrifugal tachometer is shown in Fig. 20.

Every chronometric tachometer contains: a fine tooth gear, which is connected to the main drive shaft and therefore rotates at a speed proportional to the speed of the engine; a fine tooth rack or counter on another guide; and an escapement mechanism. The counter is thrown into mesh with the drive pinion and kept there for a definite period—for example, one second. This is done whether the tachometer is running at high or low speed, by the escapement, and is its most important function. It follows, therefore, that the angle through which the gear is rotated while in mesh is proportional to the speed of the engine. In order to make the instrument recording, it remains only to transform the motion of the counter into a proportionate angular rotation of the pointer on the dial. Tachometers of this type do not show variations of speed from instant to instant as it occurs, their reading at any moment being merely the average speed during the counting period. Because of these periods, if a chronometric tachometer is watched, it jumps suddenly forward or backward, even if the speed is slowly varied. This is an objectionable feature, for, after the throttle is adjusted, it is necessary to wait a whole counting period in order to see whether the adjustment has been made correctly.

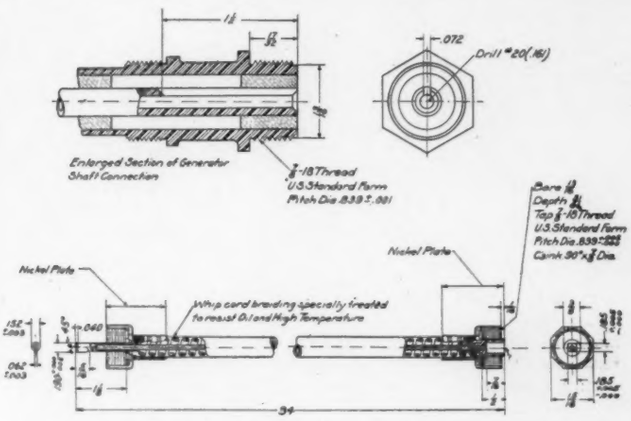

Enlarged Section of Generator Shaft Connection
Nickel Plate
Whip cord braiding specially treated to resist Oil and High Temperature
34

FIG. 21. STANDARD TACHOMETER DRIVE SHAFT CONNECTIONS

The escapement is driven automatically from the engine to avoid the necessity of winding. This is accomplished by means of a spiral watch spring, which is wound up inside of a barrel and exerts an outward pressure on the sides of the barrel. One end of this spring is fastened to a shaft and the other works free against the inside of the barrel. When the instrument begins to revolve, the spring starts turning and the barrel is set in motion by the friction of the free end. The barrel is toothed on the outside and is connected with the escapement wheel. At a certain speed the free end of the spring will begin to slip around the inside of the barrel, and the speed of the barrel will remain practically constant, and remain so as long as the instrument is in operation.

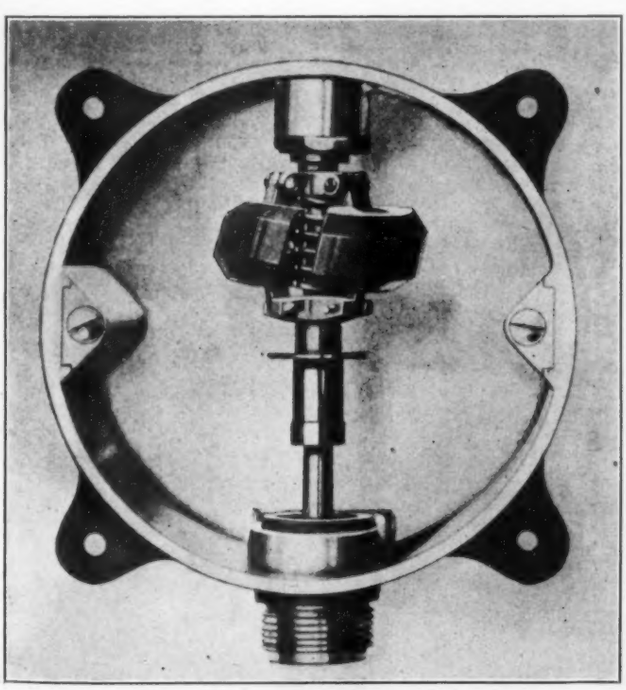


FIG. 20. CENTRIFUGAL TYPE OF TACHOMETER

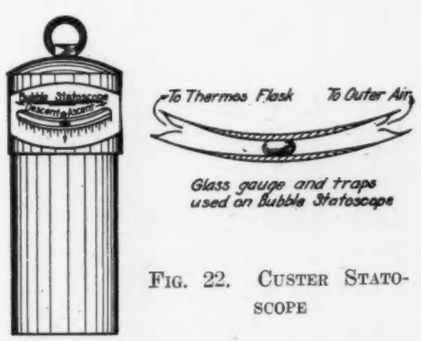


FIG. 22. CUSTER STATOSCOPE

The tachometer is driven from the engine by a flexible shaft as shown in Fig. 21. This consists of flexible twisted wire enclosed in an oil-proof casing formed by a braid-covered helical spring. The end connections are standard.

The engine must be built with a special tachometer shaft, which generally runs at half crankshaft speed. For sharp bends in the flexible shaft a special fitting has been designed.

This fitting is made up of a pair of miter gears. A similar fitting is used where it is desirable to have two tachometers on the same engine connection for use in a two-seater machine.

A tachometer should be well adjusted by the maker, and when new there is practically no error in readings at any speed. The instrument is run by a variable speed electric motor and the revolutions counted by means of a hand counter (usually Veeder) and stop-watch. The results are then plotted for true engine speed, for it must be remembered that the drive shaft only runs half-engine speed.

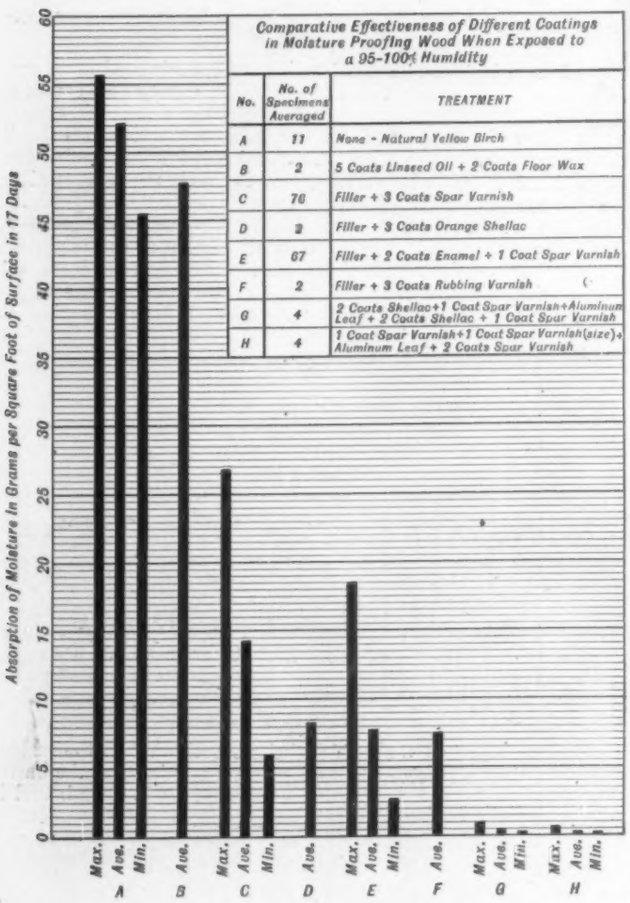
The Custer statoscope is shown in Fig. 22. It consists of a tube attached to a reservoir at one end and free at the other end. A drop of oil in the tube seals the air in the reservoir. Any small variation in the external atmospheric pressure will move the oil one way or the other in tending to equalize the pressure within the reservoir and without. The instrument is very sensitive, and an elevation of one inch can readily be seen with the naked eye. For this reason the tube is enlarged at each end, and the bubble breaks and forms over again. This action is continuous. A trap is included at each end of the tube so that the oil cannot escape in any position in which the instrument may be held. The instrument is entirely enclosed in a case of non-conducting material, so that sudden temperature changes will not affect the reading materially.

Moisture Proofing Airplane Propellers With Aluminum Leaf

By M. E. Dunlap

Architectural Assistant in Forest Products

In spite of its variability and some properties undesirable in a propeller material, wood seems to be the most satisfactory material for airplane propellers. The successful use of wood, however, depends upon overcoming or, at least, reducing to a minimum the effects of these undesirable properties, of which, perhaps, the most important is the tendency to shrink and swell with changes of moisture content.


Comparative Effectiveness of Different Coatings in Moisture Proofing Wood When Exposed to a 95-100% Humidity
No. | No. of Specimens Averaged | TREATMENT
A | 11 | None - Natural Yellow Birch
B | 2 | 5 Coats Linseed Oil + 2 Coats Floor Wax
C | 76 | Filler + 3 Coats Spar Varnish
D | 2 | Filler + 3 Coats Orange Shellac
E | 67 | Filler + 2 Coats Enamel + 1 Coat Spar Varnish
F | 2 | Filler + 3 Coats Rubbing Varnish
G | 4 | 2 Coats Shellac+1 Coat Spar Varnish+Aluminum Leaf + 2 Coats Shellac + 1 Coat Spar Varnish
H | 4 | 1 Coat Spar Varnish+1 Coat Spar Varnish(size)+ Aluminum Leaf + 2 Coats Spar Varnish
Absorption of Moisture in Grams per Square Foot of Surface in 17 Days
0
5
10
15
20
25
30
35
40
45
50
55
60
Max.
Ave.
Min.
A
B
C
D
E
F
G
H

RESULTS OF MOISTURE PROOFING

It is well known that wood is a hygroscopic material; that is, it retains a certain amount of moisture, this amount varying with the relative humidity under which the material is stored. For instance, wood stored out of doors in the northern States will retain from 10 to 12 per cent moisture, and in the drier and more arid sections, such as the States along the Mexican border, will possibly retain only 5 to 6 per cent on the average.

If a propeller is constructed under certain conditions and shipped to localities which are drier or damper, it will absorb or lose moisture according to the atmospheric conditions, unless it is protected by some sort of a coating. As a result of the absorption or loss of moisture, the propeller will lose its balance and the wood will shrink or swell and otherwise distort the blade.

A moisture-proof coating for propellers, therefore, is exceedingly desirable—(1) to produce a propeller unaffected by moisture changes, and (2) to utilize cheaper and more abundant woods such as gum, red oak and other common native hardwoods.

Experimental Moisture-Proofing Work—In the effort to develop a moisture-proof coating, an extensive series of tests was planned, including tests of many different types of coatings, such as spirit, oil and cellulose varnishes, enamels, linseed oil and wax treatments, impregnation treatments, and sprayed and electroplated metal. None of these coatings proved to be entirely satisfactory. Defects appeared in all of them, caused by lack of adhesion or inadequate resistance to the transmission of moisture. As a result of the above-mentioned work, however, an exceedingly effective, inexpensive and easily applied coating was developed. The chief feature of this coating is a layer of aluminum leaf, which is incorporated between coats of varnish.

The accompanying diagram presents the comparative results of a number of tests on the effectiveness of various coatings, and also shows clearly the progress that was made in this study to improve the coatings. At our entrance into the European war, the first specifications issued called for the finish shown at B, which it will be seen is little better than no treatment at all. The results plotted at G and H show the effectiveness of the aluminum leaf coating, which was just coming into use at the close of hostilities.

Aluminum leaf coating has been tested in service in the United States and in overseas shipments, and found to be exceedingly effective. It will resist abrasion under service conditions as well as ordinary varnish coating, but is especially valuable for protection during periods of shipment and storage so that the propeller will be perfect when placed on the machine. Repairs are readily made if abrasions do occur.

Test of Moisture-Proofing—The test used in these experiments was designed to approach service conditions. It was somewhat more severe than any tests which are likely to be met in service; that is, the normal or average moisture content for wood in France is about 15 per cent, while the condition under which the test was made would produce a moisture content in wood of from 22 to 25 per cent. The test consisted in applying the coating or treatment to a panel of yellow birch $\frac{5}{8}$ in. by 4 in. by 8 in. All surfaces were carefully coated and the specimens were hung in a compartment maintained at a relative humidity of 95 to 100 per cent. The

weights of the panels were taken at regular intervals, the gain in weight in grams per sq. ft. being used as a measure of the absorption or the amount of moisture transmitted through the coating.

Method of Applying Aluminum Leaf—Since the purpose of this coating is to moisture-proof wood thoroughly, it should be carefully applied. The leaf used is exceedingly thin and light; there are probably 12,000 to 15,000 leaves per inch, which makes it appear difficult to handle. If the suggestions outlined below are carefully followed, however, the leaf may be easily applied. While this article takes up specifically the process of coating propellers, the same procedure could be followed for coating other products.

Preparation of Surface—Careful sanding to remove all tool marks and other imperfections is required in order to insure a perfectly smooth surface over which to apply the coating.

Filling—For open-grained woods, a coat of filler consisting of 83 per cent liquid and 17 per cent silex should be used. The liquid should consist of 77 per cent airplane spar varnish and 23 per cent turpentine. The silex must pass a 200-mesh sieve. After the filler is applied to the wood and allowed to flatten, it should be rubbed off across the grain so as to fill the pores thoroughly. It should then dry for at least 24 hr., and afterward should be sanded lightly.

Shellac Varnish Undercoating—The shellac varnish should consist of 4½ lb. of orange shellac gum cut in 1 gal. of clean, neutral, denatured alcohol. This should be applied evenly over the surface of the propeller, allowed to dry 3 or 4 hr., and then sanded lightly.

Size—The size should consist of 75 per cent airplane spar varnish and 25 per cent turpentine. It is suggested that a small amount of Prussian blue in Japan be added to the varnish to give it a color so that spots subsequently left uncovered by the leaf will be readily visible.

The size should be brushed evenly over the surface as sparingly as possible, and allowed to dry until a tack is reached. This will permit the handling of the propeller immediately after the application of the leaf without disturbing the coating. The time will vary with the varnish and the weather. The varnish should dry for about 1½ hr. on a light, dry day or in a heated building in the winter time, but a longer time may be required on a cloudy or damp day. This is an exceedingly important point, and should be carefully considered, since the coating hardens very slowly after the leaf is applied.

In applying the size, care should be exercised not to produce fatty edges or runs. If they occur, the leaf will be easily rubbed from the surface in handling the blade. For convenience in applying the leaf later, it is best to size one side of the blade at a time.

Handling Aluminum Leaf—As soon as the size has reached the right tack, the leaf should be applied very rapidly over the surface. After the sized surface has been entirely covered, the leaf should be patted down with the palm of the hand or with a pad of cotton, and the rough edges should then be rubbed away. (See Fig. 6.) Any points not covered with leaf should be coated by applying a small piece of leaf to the spot with the fingers. The coating should be rubbed well with a piece of cotton which has been dipped in aluminum powder. This will insure the leaf sticking securely over the entire surface, and will fill any small holes not already filled.

Aluminum leaf comes in packs containing 500 leaves. The pack is divided up into 10 or 20 books containing 50 or 25 leaves, respectively. The metal leaf is placed between the pages of these books and is in 4-in., 4½-in., 5-in. or 5½-in. squares.

Fig. 1. Method Used in Turning Page of Book

Fig. 2. Transferring Book from Left to Right Hand

Fig. 3. Method of Holding Book When Applying Leaf

Fig. 4. First Operation in Laying Leaf

Fig. 5. Second Operation in Laying Leaf

Fig. 6. Smoothing Off Surface After Applying Leaf

Fig. 7. Applying Leaf to Large Hub Hole

Fig. 8. Smoothing Off Leaf in Hub Hole

Fig. 9. Two Propellers Completely Coated with Leaf

It is best to apply the leaf directly from the book by turning back the first page halfway and holding it (Fig. 3) between the first and second fingers of the right hand. The book itself should be held between the thumb and fingers, and in such a way that the back of the hand will be toward the work when the leaf is applied, the book being given a slight bend to prevent the corners of the leaf from drooping. The end of the leaf, exposed by turning back the first page of the book, should be placed against the surface to be coated (Fig. 4) and held securely in place by the left hand. The sheet held between the first and second fingers should be drawn back (Fig. 5) so as to allow the whole leaf to come in contact with the surface. The next sheet should be applied in a like manner, lapping edges with the first, and so on. The best results will be obtained if the gilder works in the same direction with each row of leaf; that is, from left to right. If this is done it will aid considerably in completing and smoothing off the surface. Fig. 9 shows two propellers completely coated with the leaf.

It is suggested that in turning the pages of the book (Fig. 1), the back be held between the first two fingers of the left hand. The leaves from which the leaf has been removed should be turned back and held between the thumb and first finger of the left hand. The next sheet of paper may then be turned back, exposing one-half of the next leaf. The operation of changing the book from left to right hand is shown in Fig. 2.

Large Hub Hole—The large hub hole should receive the same treatment as the rest of the propeller. In applying the leaf to the hub hole, it is convenient to cut the books of leaf up into about 1 in. strips of leaf and paper, drop the strips (Fig. 7) vertically into the opening, and bring them into contact with the size. After the entire surface of the hole has been covered it should be patted into place (Fig. 8) with a wad of cotton attached to the end of a stick.

Small Hub Holes—These holes should be corked up with ordinary corks, the tops of which should be cut off flush with the surface of the propeller and covered with the regular finish.

Shellac Color Varnish—After the application of the leaf, two coats of a shellac color varnish should be applied. This varnish should be made as described under the heading "Shellac Varnish Undercoating," except that enough color should be added to produce the desired shade. Four or five per cent bismarck brown in the shellac varnish will produce a desirable mahogany color. The amount of this material needed to get the best results should be determined by trial. The varnish should dry three or four hours before rubbing or re-coating.

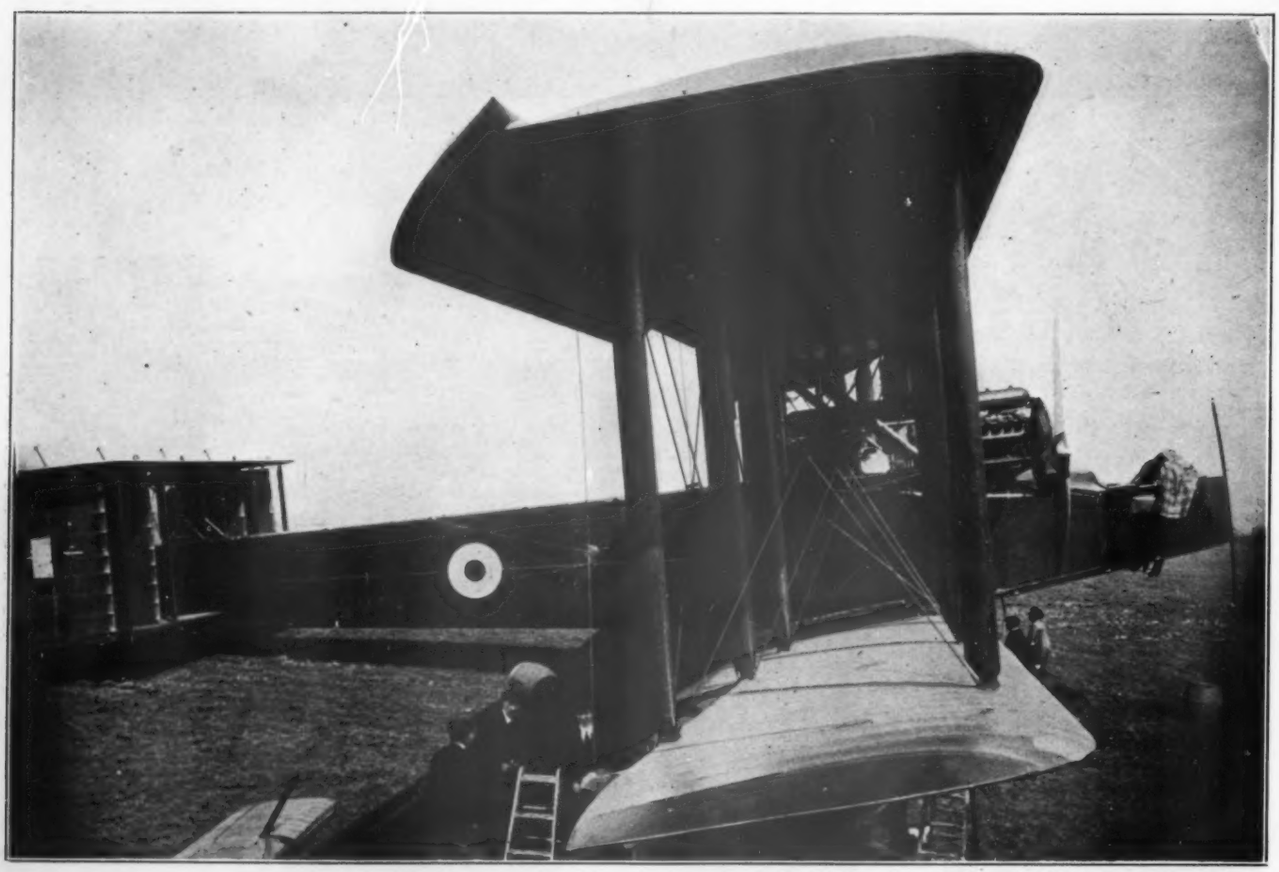
Each coat of shellac should be rubbed down lightly between coats without the use of oil.

Finishing Varnish—A final flowing coat of airplane spar varnish should be applied and allowed to dry about 48 hr. This coating should not be rubbed or sanded.

Estimated Time Required to Coat a Propeller—The time required to apply the leaf to a propeller should not be more than 40 or 50 minutes. This could be reduced after the finisher becomes more experienced. The estimated time for applying the complete finish described would be in the neighborhood of 8 or 10 hr., and the entire total time needed for drying the various coats about 90 hr. The total time required for all operations would probably be in the neighborhood of 100 hr.

Modifications of Aluminum Leaf Spirit Varnish Process—It might be desirable in some cases to use oil varnishes or enamels in lieu of the shellac described above. This may be done and satisfactory results obtained. If oil varnishes are substituted, a more durable coating may possibly be obtained, but it requires a much longer time to apply the finish because of the slowness with which oil varnishes dry. Each coat of varnish should dry at least 72 hr. before re-coating.

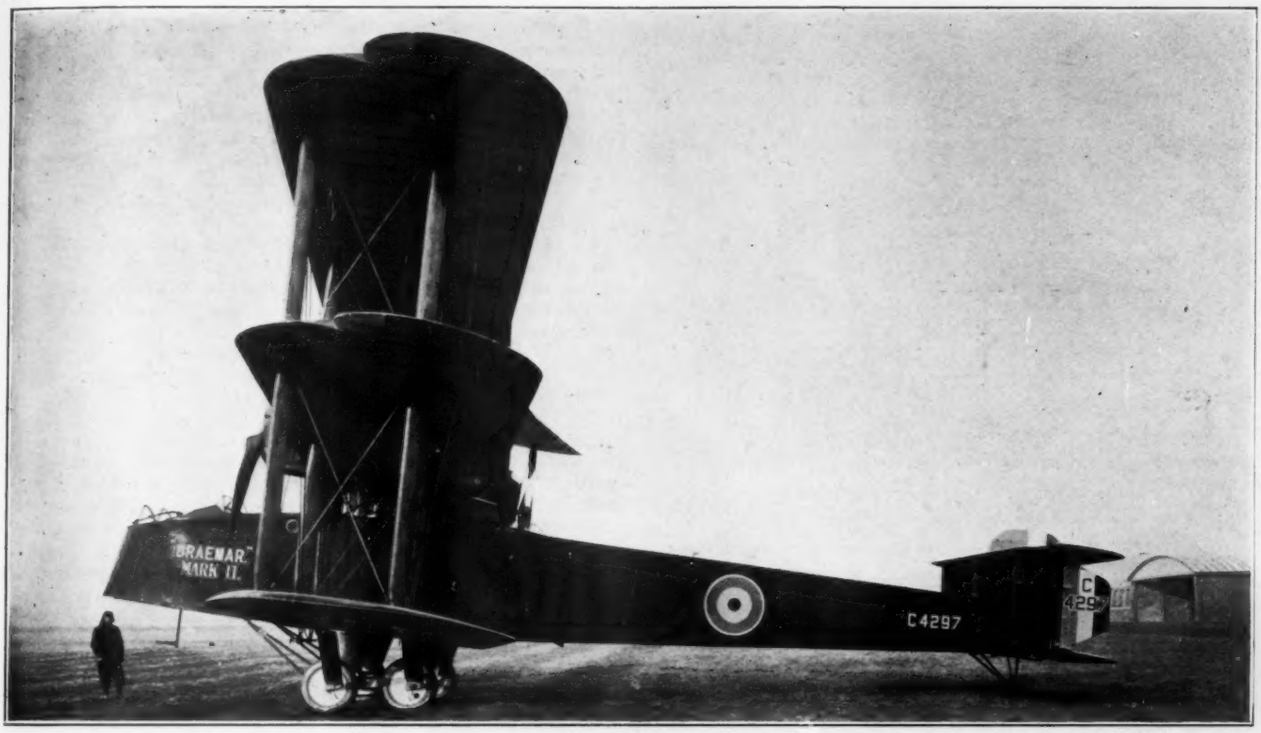
Acknowledgment—Acknowledgment is made of valuable suggestions and co-operation extended the Forest Products Laboratory by the Airplane Engineering Department, Bureau of Aircraft Production, United States Army, at McCook Field, Dayton, Ohio, and by Mr. D. A. Kohr of Lowe Bros., Dayton, Ohio, in carrying out this work.



SIDE VIEW OF A FOUR-ENGINE HANDLEY-PAGE BIPLANE

The Bristol Triplane Braemar

The Bristol triplane Braemar was constructed to provide a machine capable of maintaining a high speed during a protracted flight, and of bearing a considerable load in addition to the weight of crew and fuel. In particular it was intended to be used for the bombing of Berlin and other interior German towns. The driving power is supplied by four 400-hp. Liberty engines, fitted tandem, in pairs, on either side of the fuselage, thus considerably reducing the head resistance. The main specifications of this model are as follows:



WEIGHTS AND DIMENSIONS

Weight, empty		11,000 lb.
Weight, loaded		17,750 lb.
Wing span	Top plane	81 ft. 8 in.
	Center plane	81 ft. 8 in.
	Bottom plane	78 ft. 3 in.
Chord of wing		8 ft. 6 in.
Overall length		52 ft. 0 in.
Maximum height		20 ft. 0 in.
Wing area		1,905 sq. ft.

The machine can carry, in addition to its two pilots and sufficient gasoline, oil and water for a 600-mile flight, some 1600 lb. of cargo. The two pilots' seats are placed side by side in the fore part of the body and some distance ahead of the leading edges of the planes, while the extreme nose is occupied by the gunner with two Lewis guns. Well aft in the body is another gunner's cockpit, and a fourth gun is mounted on the floor of the fuselage. The equipment of the Braemar as a bomber is as follows:

Guns—Four Lewis guns, two of which are mounted on rotating mountings, one on a rocking pillar mounting and one on an inverted bow mounting.

Bomb Stowage—Cells for six 250-lb. bombs, or twelve 112-lb. bombs and five 50-lb. bombs.

Instruments—

On dashboard:
- 2 air speed indicators
- 4 radiator thermometers
- 4 revolution indicators
- 4 liberty switches and voltmeters
- 1 switchbox for electric lighting
- 1 altimeter
- 1 cross level
- 1 watch

Electric lighting set for each instrument.

Below dashboard:
- 1 compass.

In forward compartment: } for bomb dropping
- 1 air speed indicator
- 1 altimeter
- 1 high altitude bomb sight.

Rear of pilot's seat: } for bomb dropping
- 1 air speed indicator
- 1 altimeter
- 1 gyro bomb sight
- Flowmeters for gasoline.

On engine housings:
- 4 oil pressure gages.

The performances of this type are:

Speeds—At ground level, 125 m.p.h.; at 5000 ft., 122 m.p.h.; at 10,000 ft., 113 m.p.h.; landing speed, 55 m.p.h.

Climb—To 5000 ft. in 5 min.; to 10,000 ft. in 12 min.

With a light load the machine has a ceiling of some 20,000 ft.

For commercial purposes, whether for the carriage of passengers or of freight, a special body has been designed and constructed for the Braemar. The passenger car, described as the Pullman, is wholly enclosed, while the seats are placed on either side of a central gangway. There is ample head room, as the Pullman is some seven feet in height, and for each passenger large triplex glass windows are provided. There are also elaborate arrangements for electric lighting and heating. The seats are so arranged as to be easily removable, and the space thus rendered available can be utilized for the stowage of baggage and general cargo. The storage room thus available for cargo is 320 cu. ft.

The performances of this model in respect of speed, climb, range and weight carried are approximately the same as for the bomber. Bearing in mind that the useful weight carried is in inverse ratio to the quantity of fuel carried and the consequent range of flight, one can gather that in addition to the two pilots, the machine is capable of lifting a load of 2700 lb., together with fuel for a 5-hr. flight, or, alternatively, 4000 lb., with fuel for 7⅛-hr. flight. These figures are based on an economical speed of from 100 to 105 m.p.h.; that is to say, at three-quarters throttle, leaving a sufficient reserve of power in hand to reach 125 m.p.h. if necessary.

Airplane and Seaplane Engineering*

By Commander H. C. Richardson, U. S. N.

The work of seaplanes abroad was that of submarine patrol and convoy work, and this having been determined on, all efforts were made to obtain the most suitable seaplanes for the service. The principal work was done with two types of seaplanes namely, the HS-2—the single-motored plane developed from the HS-1—and the H-16, a copy of the English seaplane of the same type developed as a result of Commander Porte's experience with the original America and subsequent types developed therefrom. Finally, the F-5-L type was developed from English designs for manufacture in this country by the Naval Aircraft Factory at Philadelphia. The HS-2 and the H-16 have proved well suited to the work required, but the F-5-L did not enter production early enough to get into active service before the armistice was declared.

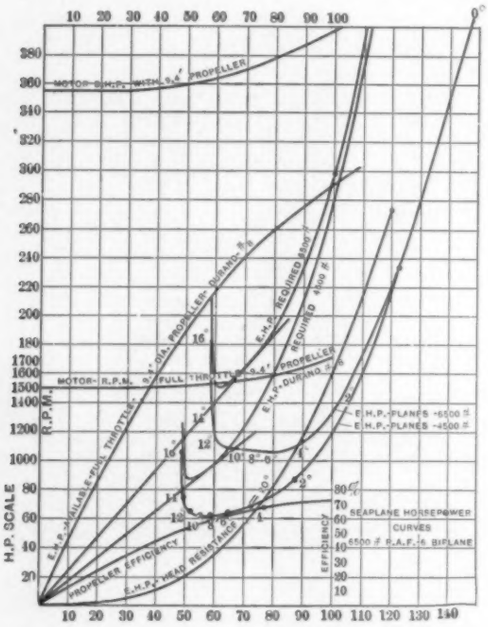


FIG. 1. HORSEPOWER CURVES OF THE RAF-6 BIPLANE

The Navy did not attempt to develop land plane types, but accepted and used those which had been developed and produced for the Army, adopting for this purpose the English Handley-Page, the Italian Caproni and the Army DH-4 and DH-9.

In order that pilots should be trained for this service, it was necessary to adopt training planes, and for this purpose the Navy developed and used the Curtiss N-9, the R-6 and the R-9, the Aeromarine and Boeing seaplanes, and the F-boat, and also experimented with a number of miscellaneous types, such as the Gnome scouts—both biplane and triplane of Curtiss and Thomas manufacture—and the Gallaudet D-5. The most successful of these training planes was the N-9, particularly after the original float had been modified and later on after the substitution of the Hispano-Suiza 130-hp. engine for the OXX 100-hp. engine. This plane was a biplane tractor with a single center float, having wing tip balancing floats. It was remarkably strong and could perform practically all sorts of maneuvers. Although in training work it was frequently wrecked, there were remarkably few deaths resulting. This I attribute to its moderate speed, great strength of construction and tractor arrangement, which made it suitable for training purposes.

As soon as it was determined that seaplanes of the flying-boat type were to be used in service it became necessary to provide preliminary training in a type of seaplane which more nearly represented the conditions of operation of the big boats. For this purpose the F-boat originally developed by Curtiss for sporting and for naval use was modified and adapted to instruction purposes.

Form and Proportion of Wings

In preliminary estimates the influence of the form and proportion of the wings is carefully estimated, and from these estimates a fairly accurate approximation of the horsepower required for the planes is derived. To arrive at the total horsepower required, it is next necessary to consider the horsepower required to overcome the head resistance. In order to do so, it is necessary to have accurate knowledge of the resistance of all elements of the airplane structure exclusive of wings, which are exposed to the action of the wind in flight.

To reduce the resistance of these elements to a minimum, streamline forms are adopted wherever practicable, and even the truss wiring is made up of streamline form; or, if this is not found practicable these wires are covered with false streamline covers of wood or metal. It is found that the reduction in resistance more than compensates for the additional weight involved in applying these false covers.

The resistance of the fuselages, radiators, engines, tail control surfaces, elevator rudder, aileron horns and all other elements is computed in detail, and account is also taken of the obliquity of these elements to the flow of the air. Such obliquity is found to exert an important influence on their action. For preliminary estimates, it is customary to determine the resistance of these elements for the position assumed by them at some speed intermediate to the low flying speed and to the high speed attainable with full power, and then to assume that the resistance of these elements is proportional to the square of the speed for speeds above and below the intermediate speeds selected. This is most handily done by assuming that the resistance of these elements is represented by a flat surface exposed normal to the wind, which would have the same resistance as the aggregate of these elements. This suppositious surface is what is referred to when we speak of the "surface of equivalent head resistance." In the example which I have chosen to illustrate, "the equivalent head resistance" is assumed to be 20 sq. ft., and the horsepower required to drive this head resistance through the air is indicated on the curve denoted head resistance horsepower. By compounding the ordinates of this curve with the ordinates of the plane's e.hp. curve we derive the total e.hp. required curve (Fig. 1).

We have next to determine the total brake horsepower available in order to determine the performance of the airplane. To determine this curve, we must first know the full-throttle characteristic of the engines to be used. This characteristic is indicated in the example showing the brake horsepower available at different speeds.

The next thing to be determined, and the one having a most important influence on the performance of the airplane, is the propeller characteristic. To date the progress in propeller design has been far from satisfactory, and although good results have been obtained, the best results have seldom been approached. In the selection of the propeller, one of the first considerations is to determine what feature of performance is most important, for it is necessary to select the proper dimensions with a view to gaining the best results for the service intended. For instance, if high-speed is of greatest importance, the propeller to be selected will differ materially from that which would be required if great climbing power is desired, because the greatest climbing power will be attained at a speed much lower than the maximum rate. Or, it may be a question of selecting a propeller which will give the greatest efficiency at cruising speed, and this propeller will usually differ from that selected in either of the preceding cases. In some cases it may be desirable to select a propeller which will give the best all-round performance rather than for a particular condition.

In seaplane work a problem arises which is not found in the land airplanes. This problem is that of obtaining the greatest reserve of power to overcome the resistance of the

* Excerpt from a paper read at the annual meeting of the Society of Automotive Engineers.

float system, because it is desirable to have the greatest possible reserve to accelerate rapidly on the water, so that the get away may be made in rough water with the greatest possible rapidity, thereby reducing the punishment which the seaplane suffers under such conditions. For a heavily loaded seaplane this consideration may be of vital importance.

Efficiency of the Propeller

It must be understood that the efficiency of an airplane propeller is absolutely dependent upon its speed of advance through the air, as is also the power which the propeller absorbs in flight, the result being that even though the full throttle is used the engine cannot make its full revolutions until a good flying speed is attained, with the consequence that full power of the motor cannot be realized until flying speed is attained.

The efficiency of a propeller is dependent upon a function of the velocity and the number of revolutions and the diameter of the propeller represented by the fraction $\frac{V}{ND}$. The efficiency, the torque and the thrust, the horsepower absorbed and the horsepower delivered are functions of this quantity, in which velocity, the number of revolutions and the diameter must be expressed in the same units.

The influence of this factor is indicated on the propeller efficiency curve based on the values of the fraction $\frac{V}{ND}$. When this fraction equals 0.2 the efficiency of the propeller indicated in the example is only 37.5 per cent. The maximum efficiency is attained when the value of this fraction is 0.59, the maximum efficiency indicated in this case being 73.2 per cent.

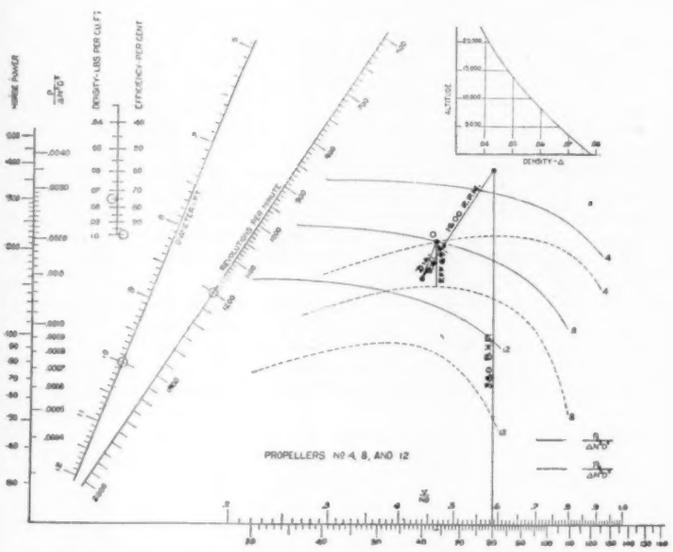


FIG. 2. CHART FOR DETERMINING PROPELLER DIMENSIONS

In the example chosen I have used a Durand propeller No. 8, the characteristics of which have been determined by wind-tunnel tests, as reported in report No. 14 of the proceedings of the National Advisory Committee for Aeronautics —1914. (See Fig. 2.)

To derive the dimensions for this propeller I have assumed that it is desired to attain the best results at 80 miles per hr. with a Liberty engine operating at 1600 r.p.m. and developing 380 b.hp., as shown by the motor characteristic. In Professor Durand's report he has adopted Eiffel's logarithmatic chart, and I shall now indicate how the diameter of the propeller is determined.

On the chart at a speed of 80 miles per hr. erect an ordinate equal to 380 hp. taken from the scale on the left side of the chart. From the top of this ordinate next draw an oblique line parallel to the line indicating the speed, and draw this line of such a length and in such a direction as to represent 1600 r.p.m. on the scale starting with the origin at 1200 h.p.m. From the extremeity of this line next draw a line parallel to the line giving the diameter scale, and taking the distance from this point to its intersection with the propeller characteristic for the propeller No. 8 we find that this line intersects at the point O. Transferring the length of this line to the diameter scale and measuring in the direction in which it is necessary to draw this line to make it intersect with the propeller's characteristic, we find that the proper diameter to use is 9.4 ft., indicating an efficiency of 69 per cent. By the use of this ingenious chart it is possible to select a proper diameter for a given set of conditions by a simple graphical solution.

The diameter now being determined, it is next necessary to determine the performance of the combined engine and propeller, and this is done as follows: On a transparent sheet of paper or tracing cloth a base line is drawn and, from any convenient point on this line, another is now drawn parallel to the scale of propeller diameters and a distance is laid off representing the diamater of the propeller on that scale. From the extremity of this line a new line is drawn parallel to the scale of revolutions per minute, and on this line is indicated the revolutions per minute of the power plant, using the scale of r.p.m. for this purpose. From each point representing the different revolutions vertical ordinates are now drawn, representing, according to the horsepower scale, the brake horsepower developed by the engine at these revolutions, and through the points so determined a motor b.hp. curve is drawn. (See Fig. 3.)

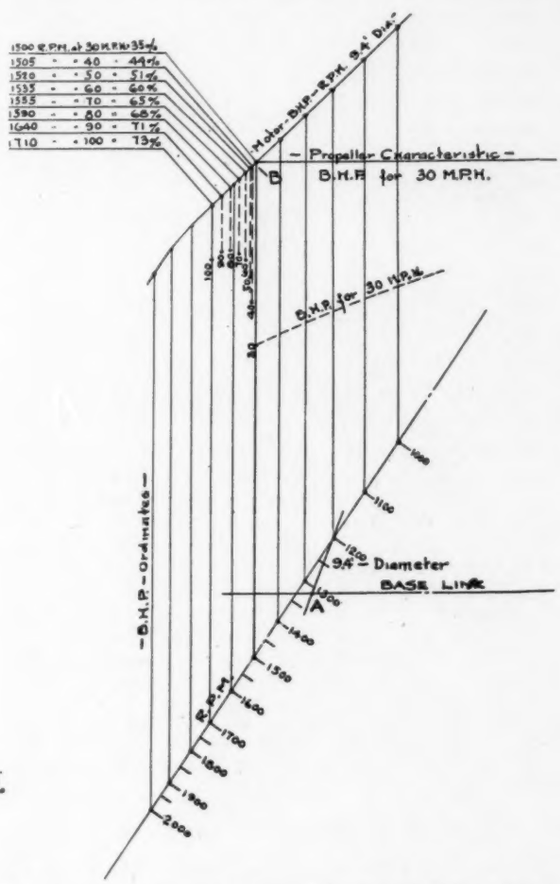


FIG. 3. CHART FOR DETERMINING THE PERFORMANCE OF A LIBERTY-12 AND A DURAND NO. 8 PROPELLER

Next place this diagram on top of the logarithmatic diagram of the propeller, placing the origin on the base line A on the base line of the logarithmatic diagram with the point A at the speed at which it is desired to determine the brake horsepower available. The propeller efficiency, and from the latter the e.hp. available, can now be determined.

This construction is based on the fact that the horsepower

absorbed by the propeller and the horsepower delivered by the engine must agree. Thus, for example, placing the point *A* at a speed of 30 miles per hr. it is found that the brake horsepower curve of the diagram intersects the propeller characteristic and the engine characteristic at a point *B*, indicating that the engine will make 1500 r.p.m. and develop 355 b.hp. at this speed of advance.

By drawing a vertical line through this point of intersection of the two curves to the dotted characteristic of the same propeller, the e.hp. developed by the propeller may be determined. This can also be determined by measuring the distance on the vertical line between the full line and dotted line representing the propeller characteristics. By transferring the length of this line to the scale for efficiency, the propeller efficiency can be determined.

In this manner the brake horsepower available and the e.hp. available have been determined and are shown on the horsepower curves in Fig. 4. It will be seen that at 30

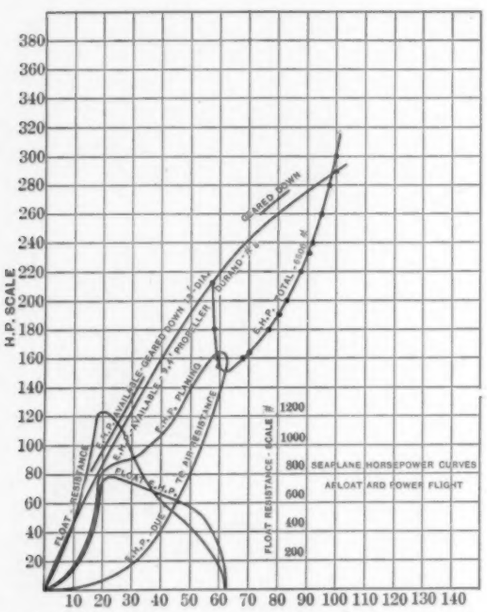


FIG. 4. SEAPLANE HORSEPOWER CURVES AFLOAT AND FLYING

miles per hr. the engine can only turn the propeller at 1500 r.p.m., developing 555 b.hp. Also, that at this speed the efficiency is only 35 per cent and only 124 e.hp. is available, although the engine is developing 355 b.hp.

Determining Plane Performance

Having now determined the e.hp. available, we are ready to determine the performance of the airplane. It will be noted that the lowest speed indicated in power flight is 58.9 miles per hr. Thus these two points of performance are determined.

The climbing power of the airplane with full power is determined by taking the difference of the e.hp. required and e.hp. available at the particular speed at which the airplane is flown in the climb. This difference is greatest at the speed of 73 miles per hr. The climb is determined from the reserve e.hp. available, which in this case is 76. Multiplying this e.hp. by 33,000 and dividing by the weight of the airplane, assumed in the example to be 6500 lb., it is found that the initial climb should be 386 ft. per min.

Further inspection of the curves shows that the minimum horsepower is required at a speed of 62 miles per hr. It is at this speed that the airplanes should be flown to get the greatest endurance. If, however, it is desired to get the greatest range, the most favorable speed will be indicated by drawing a tangent from the origin to the e.hp. required curve, as at this point the most favorable ratio is attained between velocity and horsepower required.

In the example this speed is found to be higher than the speed for minimum power and is about 73 miles per hr. It will be noted that the tangent to the curve substantially conforms to the curve over the range of speed from 70 to 76 miles per hr. If the endeavor is being made to cover the greatest possible distance, it would be desirable to select the higher of these two speeds, for the reason that at the higher speed the controls would be more effective; the flight would be steadier and would be accomplished in a shorter time.

As the airplane proceeds its weight will be reduced because of the consumption of fuel, and with a plane of heavy carrying capacity this reduction of fuel at the end of a long flight will appreciably reduce the load and thereby decrease the horsepower required for flight.

In the example chosen, I have indicated the horsepower required when all the fuel is used up, assuming a weight at this time of 4500 lb. In this condition the most efficient speed will again be indicated by a tangent to the origin, and in the example this speed is appreciably lower than that indicated for the full load condition, being anywhere from 55 to 60 miles per hour. At intermediate stages intermediate speeds will be found the best for the greatest range. This, therefore, indicates that in planning a long-distance flight due account should be given to this effect, as the radius of flight will be appreciably increased if proper account is taken of the influence of change in weight. To be exact, the tangent should not be drawn to the e.hp, required curve, but to a set of curves which can be derived from these curves indicating the fuel consumption at different speeds and at different loads. The determination of the fuel consumption curves is a simple matter, but it would take more time and space than I consider it desirable to give in this paper. I can state, however, that the favorable speeds for long-distance cruising are not appreciably affected by using these fuel consumption curves in preference to the e.hp. required curves.

The computations made in deriving the curves shown have been based on the Liberty engine, using straight drive. If it were possible to have available the same power with the geared-down propeller, it would be possible to greatly improve the propeller efficiency and thereby to improve the performance of the airplane indicated in the example. It is unfortunate that the geared-down engine is not available for general use, as the performance of practically every plane I know of using this engine in our country would be materially improved by its use. An inspection of the $\frac{V}{ND}$ efficiency plot will make this clear. I also consider it unfortunate that in the development of the geared-down Liberty engines which have been produced, advantage has not been taken of the possibility of locating the propeller more centrally in relation to the engine group, because of the advantages which would be gained in streamlining. This engine is extremely awkward to streamline in its present form.

Design of Seaplane Floats

I will now proceed to the consideration of some of the elements of design to seaplane floats. The requirements of seaplane floats, because of the nature of their use, are necessarily conflicting, and the best that can be done is to make a compromise, bearing these in mind.

The first requirement of a float is that it shall be seaworthy. This requires that the form shall be properly proportioned to provide good initial stability and a reserve of buoyancy. This is necessary to obtain a reserve of stability, as the seaplane must float without capsizing in a sea-way and in strong winds. This requirement in itself conflicts with airworthiness and lightness and with the adoption of the best streamline form, which otherwise would be, in general, a form similar to a dirigible. It must be strong, but this naturally conflicts with lightness. It must also have good planing qualities, and this requirement conflicts with streamline form. Airworthiness requires that it should have the minimum resistance and interfere in the least possible degree with the other characteristics of the seaplane.

In order to develop the best form of hull, the Navy Department began experiments at the Washington model basin late in 1911. These experiments were initiated by Capt. W. I. Chambers, U. S. N., with a view to the use of hydroplane blades, such as had been used by Forlanini, and to improving the planing qualities of the then existing types of floats. At that time the most successful float was that constructed by Glenn H. Curtiss, having a simple box section and a sled-form profile. At the same time Burgess had developed twin

floats having a single step, which had also proved successful.

One of the earliest experiments at the model basin was an attempt to reduce the wetted surface to a minimum by the use of a semi-circular section in the form of a half-cylinder whose ends were pointed like a projectile to reduce the air and water resistance. It was fortunate that this model was tried among the first, for its trials at once showed up a factor which later was discovered to be of the greatest importance, this factor being suction, due to downward curved surfaces when exposed to the contact of water at high speeds. It was at once realized that in the test of the floats due allowance should be made to represent the change in load carried by the float as the speed of the seaplane increased and the lift of the wings became an important factor, and all runs at the model basin had been made taking account of this and determining for each particular speed the "corresponding displacement" of the float. This was originally done by counterweighting the float so that the weight resting on the water represented that which would be the case taking into account the auxiliary lifting power of the wings. In the latest form of apparatus for testing at the basin this compensation is automatically made by the use of an inclined vane submerged in the model basin, which, by means of a system of pulleys, exerts a lifting power which is proportional to the lifting power of the wings at the speed at which the test is run.

In the tests with the semi-cylindrical model above referred to, it was found, as anticipated, that the resistance at low and moderate speeds was less than that experienced with other models, but as one-half of the speed for the get away was approached, and therefore the float carried only three-quarters of the original load, it was found that the resistance of this model instead of decreasing, increased; and that the model, instead of planing, as was expected, settled into the water and, finally, at the get-away speed, with no weight being carried by the float but the float just in contact with the water, the influence of suction was so great that this model, instead of skimming the surface, proceeded to envelope itself in water and was drawn down so sharply by suction that its deck was flushed with the surface of the water in the tank and great sheets of spray were lifted clear of the surface of the model basin.

As the work progressed the models of every known successful type of float were tried in the model basin, and data were collected as to the performance of these models. At the same time many experimental models were tried, and when these showed improvement over existing types, full-sized floats were constructed and tried out in actual flight. From these trials it was found that the conditions indicated in the model basin were duplicated in practice with full size, and it was seen that the model basin tests formed a means of predicting the performance of full-sized floats.

The steps of the Burgess floats were ventilated, and an investigation of this feature showed the value of ventilation for the step-type floats then in use.

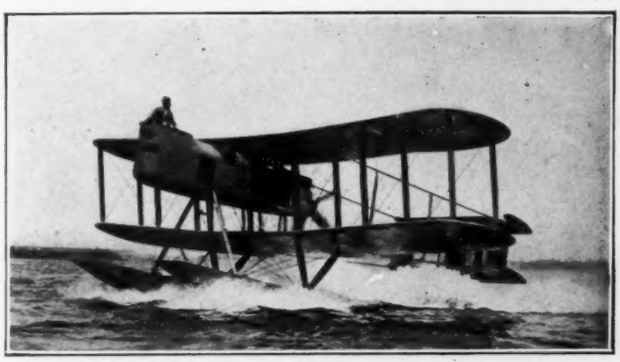
All sorts of bow forms were tried and were shown to have very little influence on performance. The use of one, two, three and four steps was tried, and the indications were that there was little, if any, advantage to be gained by the use of more than two.

The introduction of the V-bottom showed promise of improvement, but it was early found that a V-bottom at the bow was invariably associated with large quantities of spray which would flow over the planes, and also in a cross-wind would make the navigation of the seaplanes very uncomfortable. It was found by making the lines hollow at the bow that this spray could be held down close to the water, and in some later designs this hollowness was also introduced at the step, apparently with beneficial results. After much experimenting it finally became apparent that the best form of hull was that embodying the single ventilated step, in which the after bottom rose at an angle of approximately 8 deg. to the bottom just forward of the step. The reasons for this are about as follows: With this type of float sufficient buoyancy can be provided abaft the step to eliminate the necessity of tail floats for stability. It was also found that by ventilating the step the water flowing under the forward bottom flowed over the step in the form of an inverted waterfall and that the contact of this inverted stream moved further aft as the speed increased and generally passed clear of the tail of the float just before planing was attained. At this point maximum resistance was encountered. After this point was passed the float proceeded to plane on the forward step, and because of the raised position of the tail of the float, it was then possible to vary the trim of the plane and change the angle of attack without again bringing the tail of the float into the water. Then progressively as the speed increased to flying speed the planing power of the portion forward of the step increased rapidly and the amount of wetted surface exposed to the action of the water was rapidly reduced, and the resistance of the float decreased, until finally at the get away the water resistance of the float was eliminated.

The best results are obtained where the bottom of the float just forward of the step is substantially paralled to the axis of the seaplane. This portion of the bottom should have no curvature for a distance of several feet forward of the step.

Attempts were made to curve up the portion abaft the step with a view to producing a better streamline form for the hull, but this curvature was invariably found to produce suction, retard planing, and in many cases to augment the resistance of the float to such a degree as to require an excessive reserve of horsepower in order to get away. There was one case where a flying boat was built with very moderate curvature abaft the step, but on account of this curvature in the tail was unable to leave the water with a single passenger. Even though it could get up to a speed where the step itself was clear of the water, the tail would still drag and could not be drawn out of the water. By slightly modifying the tail of the float so that the lines abaft the step were straight, this same flying boat with the same power plant was able to get off the water with a pilot and passenger.

(To be concluded)



N-1 Seaplane Taxying at High Speed, Showing Stern-Wave

Photo U. S. Naval Air Service

Book Review

Aeroplane Construction. By Sydney Camm. (128 sketches. Crosby Lockwood and Son, London. 138 pp., 128 sketches.)

The material embodied in this book was intended by the author as a broad survey of the principles and details of modern airplane construction. It was written at a time when specific references to modern British aircraft were forbidden, but the details and methods described are nevertheless fairly representative of modern machines.

The presentation of the material is excellent and the sketches are very clear. The main fault is perhaps excessive condensation, rendering it more useful for the student, than for the experienced designer. Built-up spars are fairly completely covered, but very few types of struts are discussed; likewise, the construction of ribs is very briefly covered. The fittings selected for the chapter on interplane strut connections are very representative.

In fuselage construction Mr. Camm is very sound. Undercarriage details, control systems, engine mountings, wires and connections are the headings of some other of the chapters. Granted the condensation, the book is still very interesting and valuable.

The Air Service Parachute

As the result of experiments carried out at McCook Field, the Air Service has adopted a standard type of parachute for use from disabled airplanes which is considered superior to any other type, domestic or foreign.

The Air Service parachute is designed to carry a person weighing 200 lb. traveling at 300 m.p.h.; this requirement has empirically been obtained by testing experimental parachutes carrying 400 lb. at 150 m.p.h. Specifications prescribe, however, that each service parachute shall be tested by dropping with 300 lb. at 150 m.p.h. so as not to strain the apparatus to the breaking limit.

THE AIR SERVICE PARACHUTE IN ACTION
(C) *Underwood & Underwood*

The type adopted by the Air Service is known as a flat chute, 28 ft. in diameter, with a 48-in. flexible vent. It has forty shroud lines, each of which has a breaking strength of 250 lb. These are arranged in four groups of ten each, tied to a D-ring, which in turn is sewn into the harness webbing. The strength of the cords attached to any D-ring is 2500 lb.; the D-ring has a strength of 5000 lb., while the webbing, as arranged, breaks at 3400 lb. The breast and leg straps are amply strong, while the cords, which are the weakest part, have a safety factor of at least 3 under the most extreme of the conditions named above, as a chute has already successfully passed this test with shroud lines attached to each D-ring of only 720 lb. Failure in fabric is not expected.

At present only one type of pack carrier is prescribed, but it is hoped that in the future three different types will be available so that the chute can be packed in the carrier which will most conveniently fit the airplane to be used in. This pack can be operated either by attaching the rip cord to the plane or by the aviator pulling it himself, either after or before jumping, depending upon circumstances. Of course, in the latter case it would behoove him to be out of his seat, either out on a wing or on the empennage. The attaching of the rip cord to the airplane is not recommended, but in case the aviator desires this arrangement he may simply tie a cord of the desired length into the rip cord ring and to the airplane. Such a cord is not furnished. When the rip cord is pulled, strong elastic bands come into play which pull the covers of the pack apart and release the pilot chute, which springs open. The pilot chute then pulls the top of the main chute from the pack and holds it taut and straight until it fills with air. However, in case the pilot chute fails to operate, the main chute would be blown out and opened, though not quite so rapidly.

With each chute is a sample of the fabric, cords, webbing, etc. This is marked with the serial number of the chute, as well as with its tensile strength, and should be tested at least monthly to determine its deterioration. In addition, it is thought that each month every chute on hand should be dropped, for test with a 300 lb. weight at 150 m.p.h. or the equivalent thereof.

In all live drops from airplanes so far carried out by the Air Service the engine has been throttled, and it is believed that the emergency is very remote when it will not be possible to close the throttle or cut the switch before jumping. In case the engine is idling, the problem of getting away is not difficult in normal or nearly normal flight, nor is it believed that the matter of speed itself will be bothersome within reasonable limits. There will be ample time to get out of the machine under any circumstances (provided it is far enough above the ground), before a speed is reached which would cause failure of the chute. It will of course be necessary to clear all parts of the machine.

Further experiments are to be carried out with a view to determining the best method of escape from a plane in a nose dive, spinning nose dive, etc. It is believed that this offers no considerable difficulty.

New York Landing Field

A proposal to establish municipal airplane landing fields in co-operation with the Federal Government has been presented to the Board of Estimate of New York City by Comptroller Craig, who declared that the establishment of such fields was worthy of serious attention.

"It is only a matter of a few years before aerial intercity transportation, express service, mail service, emergency service and local photographic mapping, as well as aerial protection, will be a part of the activities of every city government," Comptroller Craig added. "Assurance is given that neither the Air Service nor the Post Office Department will deal with any private individual, society or corporation in the matter of landing fields."

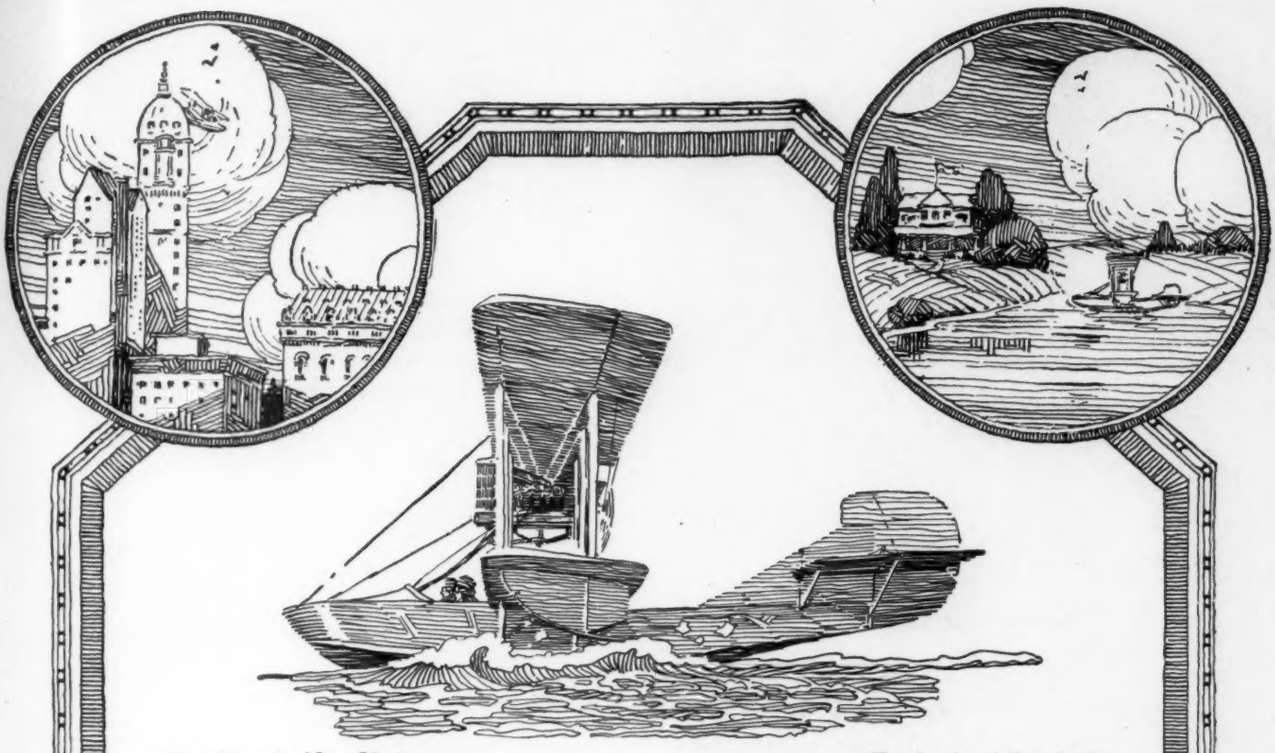
The Comptroller's proposal was prompted by a communication he received from Major-Gen. Charles T. Menoher, Director of Air Service, U. S. A., who said that should the city decide to co-operate with the Government in establishing landing fields, the Army will obligate itself to furnish hangars to be erected on the fields at the expense of the city.

The Army will also ask the city to bear the expense for establishing landing fields and the maintenance of both the fields and the equipment, exclusive of airplanes.

Loss of the C-8

The United States naval airship C-8, Lieut. N. J. Learned, U. S. N., commanding, exploded for unknown reasons and was destroyed by fire on the afternoon of July 1, in a field near Camp Holabird, Maryland, where she had landed owing to rudder trouble. A number of people were injured by the explosion.

The C-8 was sister ship of the C-5, which made an 1100-m. cruise from Montauk naval air station to St. Johns, N. F., and was subsequently torn from her moorings and blown out to sea. The C-8 was completed only recently, and on June 3 made a non-stop flight of 410 m. from Akron, O., to Cape May naval air station, Lieut.-Comdr. R. F. Paunack, U. S. N., being in command.



Breakfast in New York
Luncheon at Albany

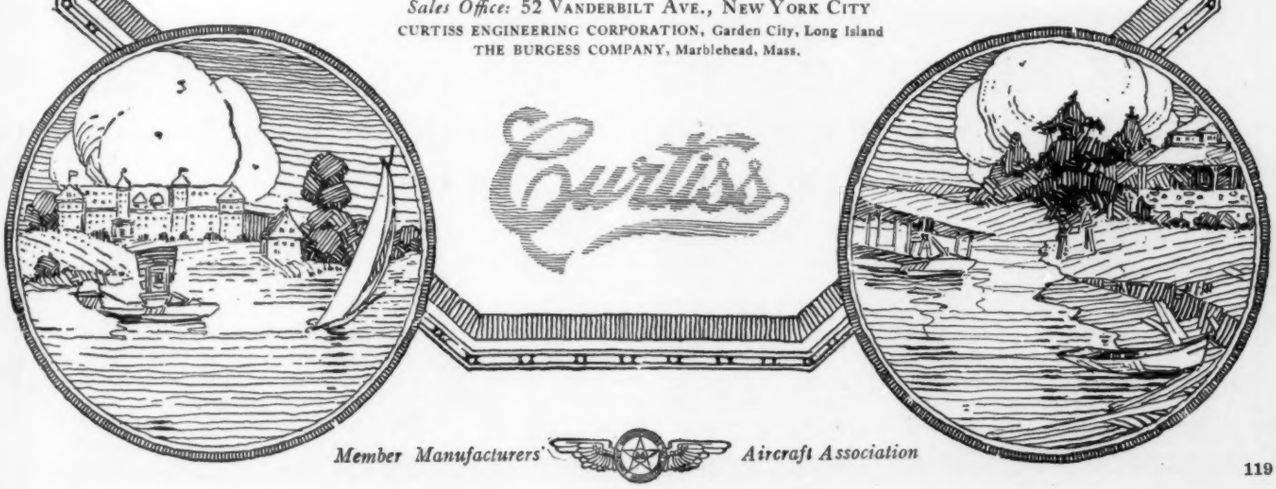
Tea in the Adirondacks
Dinner at the 1000 Islands

QUALITY in travel is exemplified in the aeroplane, and the aeroplane finds its highest quality in the smooth-riding, graceful Curtiss Flying Boat, which moves swiftly with unexampled security and ease of control.

Immediate Deliveries

CURTISS AEROPLANE AND MOTOR CORPORATION
Sales Office: 52 VANDERBILT AVE., NEW YORK CITY
CURTISS ENGINEERING CORPORATION, Garden City, Long Island
THE BURGESS COMPANY, Marblehead, Mass.

Curtiss



Member Manufacturers' Aircraft Association

Sturtevant
(REG. U.S. PAT. OFF.)

AIRPLANE ENGINES
HAVE BEEN FLYING FOR TEN YEARS

They are the product of skilled engineering and manufacturing experience running through three generations.

Latest types are now available

Sturtevant Model 5A—4½

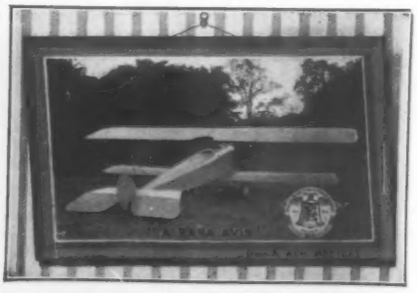
Our new Catalog, No. 259, will interest you

B. F. STURTEVANT COMPANY
HYDE PARK, BOSTON, MASSACHUSETTS

Members Manufacturers' Aircraft Association

TRUTHFULLY REVISED SAYINGS FROM POPULAR "AUTHORS":—

THE MACHINE YOU WILL EVENTUALLY FLY!



ASK ANY LONG ISLAND ARMY FLIER— HE KNOWS!

THE BELLANCA TWO-SEATER BIPLANE
EQUIPPED WITH THE **DEPENDABLE WARTIME-TESTED ANZANI "55"** CONSTITUTES
THE LOGICAL AERO BUS for

THE PROGRESSIVE MERCHANT
THE FAR-SIGHTED BUSINESS MAN
THE STUNTING EXHIBITION FLIER
THE THRILL-LOVING SPORTSMAN
THE EFFICIENT PASSENGER CARRIER
THE STEADY-GOING AVERAGE MAN

HIGHEST SAFETY FACTORS!

LOWEST UPKEEP COST!

Full Information and Specifications on Request

HARRY E. TUDOR, *Sales Manager* 299 Madison Avenue, New York City

FLEXIBILITY and versatility, resulting from combined stability and strength, commend Boeing Seaplanes to professional pilots and to sportsmen of the air. Ability to stand up under the most gruelling tests and day-in, day-out service, the result of perfected materials and refined craftsmanship, assure safety to the most daring. The greatest spruce-producing country in the world, surrounding the place of Boeing manufacture, gives its best wood to Boeing aircraft. Boeing Seaplanes combine symmetric and asymmetric stability to a degree never hitherto attained. May we address you a personal letter?

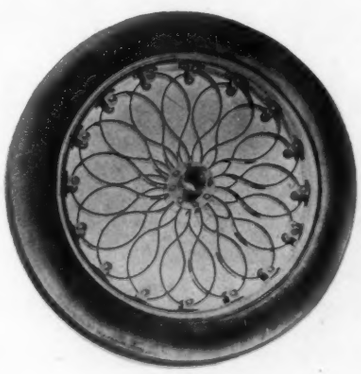
BOEING AIRPLANE COMPANY, Seattle, U. S. A.

BOEING *Seaplanes*

ATLAS WHEELS

Are daily gaining in favor with manufacturers and pilots of aircraft because:

They Absorb Shocks ***They Are Stronger*** ***They Are More Reliable***



Standard sizes carried in stock. Inquiries and orders will receive prompt attention.

THE ATLAS WHEEL COMPANY

ROCKEFELLER BUILDING CLEVELAND, OHIO

N. S. E. E.

20-P-1a

ADDRESS BUREAU OF STEAM ENGINEERING, NAVY DEPARTMENT.
AND REFER TO NO. 419433-736-5-DA

NAVY DEPARTMENT.

ENCLOSURES.

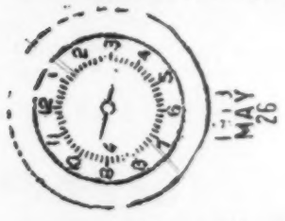
BUREAU OF STEAM ENGINEERING,
WASHINGTON, D. C.

MAY 24 1919

Gentlemen:

The bureau desires to express its appreciation of the splendid co-operation recently exhibited by your organization when you were called upon to build, in the period between 4 P.M. Saturday, May 10th, and 7 P.M. Monday, May 12th, twelve 10 ft. propellers for installation on the NC-1, NC-3 and NC-4 flying boats in their flight from Newfoundland.

The very successful manner in which you complied with this difficult request established a record of which you may well be proud.



Very respectfully,

R. R. Griffin

Engineer-in-Chief, USN.
Chief of Bureau.

American Propeller & Mfg. Co.,
Baltimore, Md.

a counterbalanced aviation crankshaft . . . .

Patented July 10th, 1917

one of the 18 different
models we are now making
for 14 aviation motor companies . . .
reduces vibration and eliminates bearing pressure

We have shipped 46,637 Aviation Crankshafts to January 16, 1919

THE PARK DROP FORGE CO. CLEVELAND, OHIO

THOMAS-MORSE

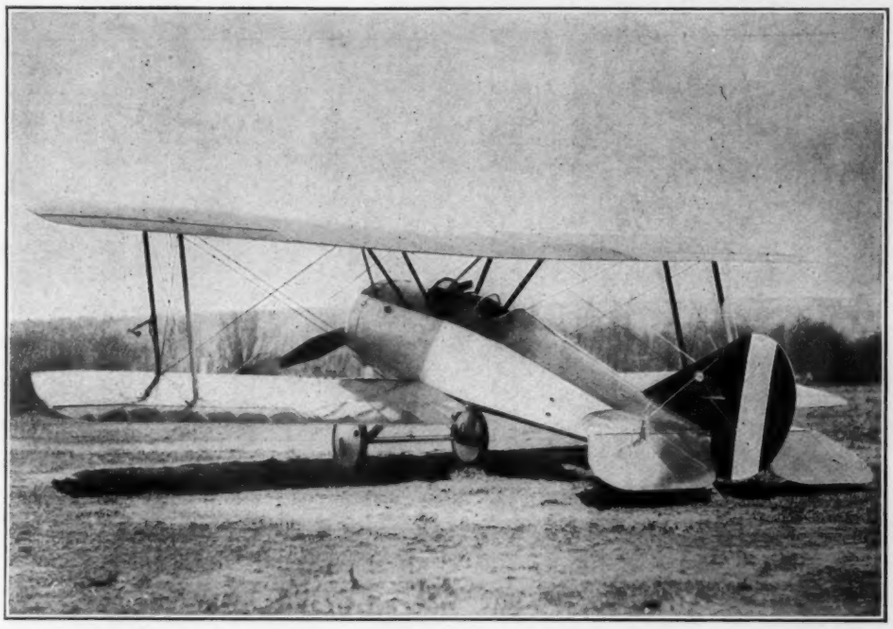
Tandem 2-Seater, Type S-6

Equipped with 80 h. p. Le Rhone Engine.

High speed, 105 M. P. H.

Landing speed 35 M. P. H.

Climb 7,800 ft. in first ten minutes.



THOMAS-MORSE AIRCRAFT CORPORATION

ITHACA, N.Y. U.S.A.

MERCHANTS FIRE ASSURANCE CORPORATION OF NEW YORK

AVIATION DEPARTMENT

Is now issuing policies covering the following hazards to aircraft:

1. Fire and Transportation
2. Collision (damage sustained by the plane itself)
3. Property Damage (damage to property of others)

Additional coverage may be had against loss by windstorm, cyclone or tornado.

AUSTEN B. CREHORE, Manager, Aviation Department. For two years pilot in Lafayette Flying Corps and previously with this company since 1910.

We should be glad to discuss with those interested the various phases of insurance on Aircraft.

MERCHANTS FIRE ASSURANCE CORPORATION OF NEW YORK

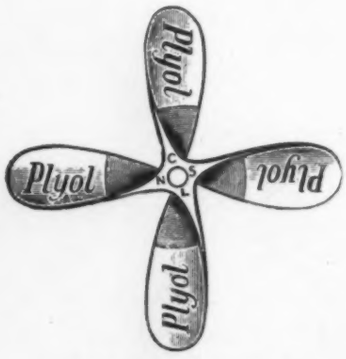
45 JOHN STREET, NEW YORK CITY

Fire—Automobile—Tornado—Explosion—Riot and Civil Commotion

"THE SEAGULL"—Sport Seaplane

L-W-F ENGINEERING COMPANY, Inc.
COLLEGE POINT, L. I.

CASEIN



REGISTERED TRADE MARK

CASEIN

Aldgate Casein Works

NIEUWHOF, SURIE & CO., Ltd.

Head Office:

5, Lloyd's Avenue London, E. C. 3

To get the Best Results with THREE-PLY VENEERING, &c., the adhesive mixture must contain

PLYOL

Telephones: { *Avenue 34* / *Avenue 35*

Telegrams: *"Suricodon, Fen, London"*

Aéroplanes VOUGHT

¶ **Vought VE-7 Type** airplanes, adopted by the U. S. Army Air Service for its standardized advanced training airplane, are now available for sportsmen and commercial use.

¶ Equipped with Hispano-Suiza 150 H.P. Motor.

Performances Guaranteed—Immediate Delivery

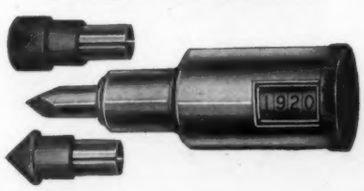
LEWIS & VOUGHT CORPORATION

WEBSTER and SEVENTH AVENUES LONG ISLAND CITY, N. Y.

You can dispense with the preliminary block test—

by finding the R.P.M. of airplane motors, prior to the final tachometer rating, with a

Veeder
SPEED COUNTER

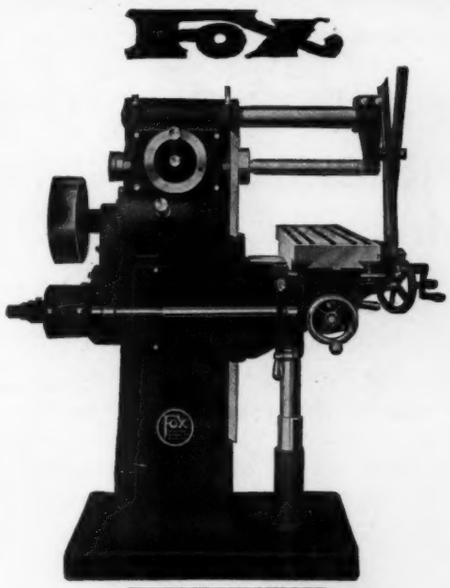


Simply hold the Veeder against revolving propeller shaft; apply slight pressure the moment you start timing; release pressure when minute is up. Clutch starts or stops recording mechanism instantly, giving accurate readings without use of stop-watch. Price, $3.00.

Veeder Counters for recording the production of machines are standard for all industrial purposes. Write for booklet.

The Veeder Mfg. Co.
56 Sargeant St., Hartford, Conn.

FOX



No. 3B PLAIN MILLER

Single Pulley Drive

12 changes to spindle speeds
6 changes to each spindle speed
No. 9 taper in spindle.
Table 8½ x 37"

Hardened machine steel gears throughout insure maximum driving power at all speeds.

We also build Universal Millers, Dividing Heads, Vertical Attachments and Vises.

Write for Circular

THE FOX MACHINE COMPANY
1810 W. Gavson St., Jackson, Mich.
Formerly of Grand Rapids, Mich.

-FOR NAVAL AVIATORS-
PILOTS CREW WATERMEN
IMPREGNABLE TO COLD, WIND, and WATER
Keeps you afloat in upright position—Chest high out of water—warm and dry indefinitely
SAVES from DROWNING and EXPOSURE
Tested, approved and used by the U. S. Army and Navy
Write for booklet A-A
SAFETY-AT-SEA CORPORATION
1358 BROADWAY NEW YORK

JOHNS-MANVILLE SERVICE
COVERS THE CONTINENT

All the experience of this organization in the manufacture of *speed* indicating and *recording* instruments, is available to the manufacturer with a problem in this field of airplane accessory apparatus.

Correspondence is invited
H.W. JOHNS-MANVILLE CO.
New York City
10 Factories—Branches in 63 Large Cities

JOHNS-MANVILLE
Speed Indicating and Recording
Aeronautic Instruments

A Dependable Source Specializing on

AIRCRAFT
PRECISION SCREW
MACHINE PRODUCTS

Preferably parts of Nickel and Alloy Steels machined from Bar Stock, held to close tolerances, hardened and ground.

A character of work where accuracy and quality are the determining factors.

Permit us to quote you on your requirements.

ERIE SPECIALTY CO.
Erie, Pa.

New York Office, 8 West 40th St.

You don't take a chance when you buy an ELDORADO. No matter what you need a pencil for, there is a *standard* ELDORADO that will give you perfect satisfaction.

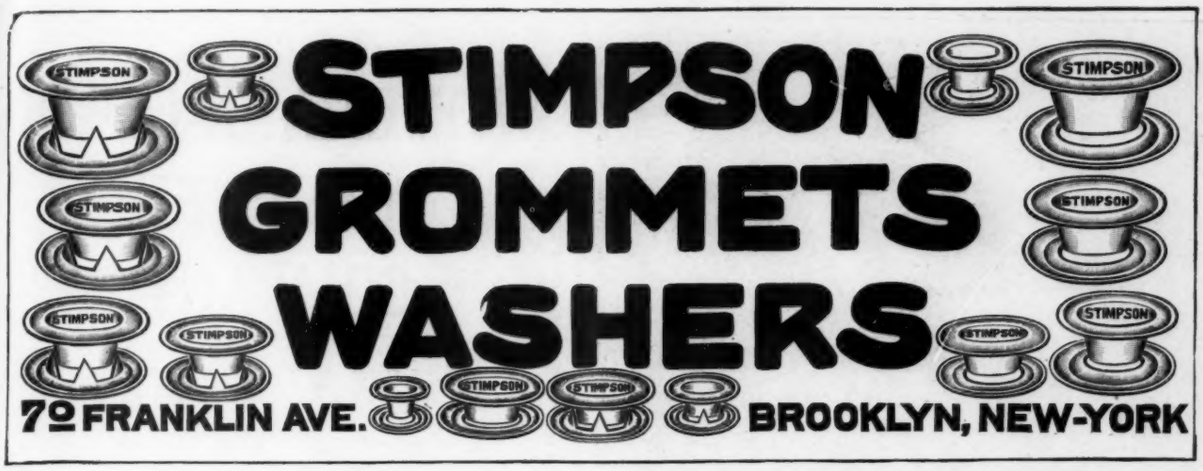
Made in 17 LEADS
one for every need or preference

Each lead is standard. Each lead is balanced according to degree—strong, long wearing, responsive and even in tone.

Write us on your letterhead for free full size samples of your favorite degrees. Please mention your dealer's name.

JOSEPH DIXON CRUCIBLE COMPANY
Dept. 146-J Jersey City, N. J.

Canadian Distributors
A. R. MacDougall & Co., Ltd., Toronto, Ont.
There is a Dixon-quality Pencil, Crayon, and Eraser for every purpose



FUEL LEVEL GAGES

This cut shows our Model 51 Gage which is standard on practically all type of military training machines.

Other types of gages in large quantities are "doing their bit" as part of the equipment of English Government Warplanes.

SPECIAL TYPES DESIGNED FOR YOUR ESPECIAL NEEDS

BOSTON AUTO GAGE CO.

8 WALTHAM STREET, BOSTON, MASS.

Aluminum Company of America

General Sales Office, 2400 Oliver Building
PITTSBURGH, PA.

Producers of Aluminum

Manufacturers of

Electrical Conductors
for Industrial, Railway and Commercial Power Distribution

also

Ingot, Sheet, Tubing, Rod, Rivets, Moulding, Extruded Shapes

also

Litot Aluminum Solders and Flux

CANADA
Northern Aluminum Co., Ltd., Toronto

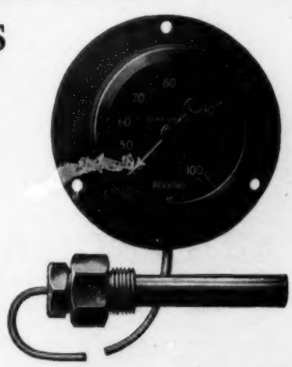
ENGLAND
Northern Aluminium Co., Ltd., London

LATIN AMERICA
Aluminum Co. of South America, Pittsburgh, Pa.

QUALITY INSTRUMENTS FOR AIRPLANES

FOXBORO
TRADE MARK

Indicating Dial Type Thermometers for circulating oil and water.
Airspeed Indicators to determine buoyancy and avoid stalling.
Oil Pressure Gauges
Air Pressure Gauges

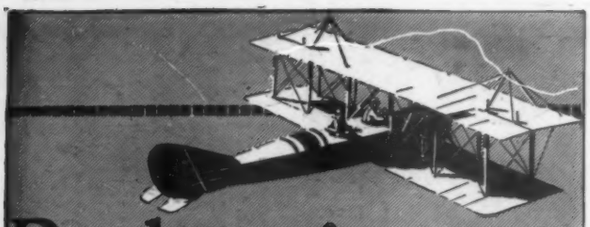


The Foxboro line includes many other types of Indicating and Recording Instruments designed for all sorts of conditions and purposes.

Bulletin No. BI-110 describes our Airplane Instruments.

THE FOXBORO CO., Inc., FOXBORO, MASS., U. S. A

New York Chicago Philadelphia Pittsburgh Peacock Bros. Montreal, Canada Birmingham San Francisco



Baker's
A-A
Castor Oil

Specially Refined
for the Lubrication of
AERONAUTICAL MOTORS

BAKER CASTOR OIL CO.
Founded 1857
The Oldest and Largest Manufacturers
of Castor Oil in the United States
120 BROADWAY - - - NEW YORK

WITTEMANN-LEWIS
AIRCRAFT
COMPANY

NEWARK, N. J.

Main Office and Factory:

Lincoln Highway
near Passaic River

Telephone, Market 9096

SPRUCE LUMBER

for

Airplane Construction

FOR twenty years we have been exclusive manufacturers of PACIFIC COAST SPRUCE LUMBER. Our product is from the very best forests of SITKA SPRUCE.

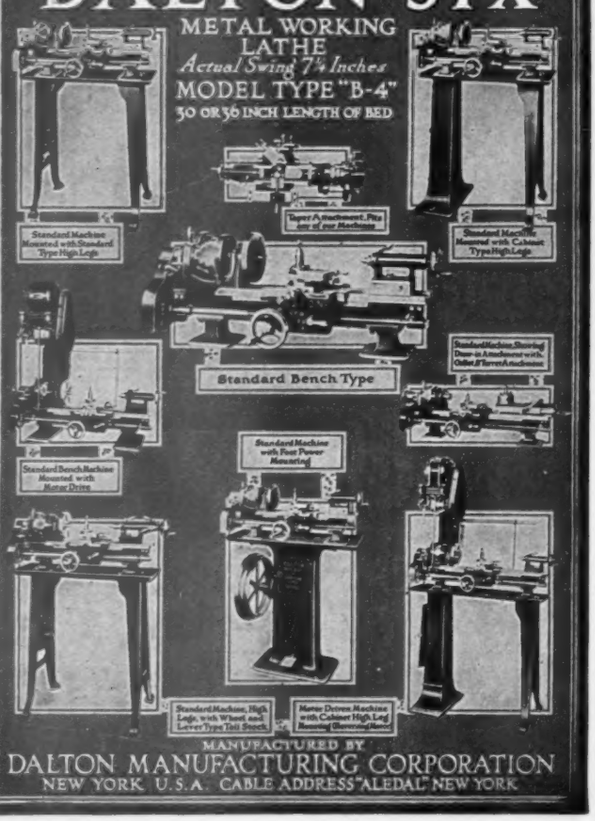
We solicit your inquiries

MULTNOMAH LUMBER
& BOX COMPANY

PORTLAND OREGON

"DALTON SIX"

METAL WORKING
LATHE
Actual Swing 7¼ Inches
MODEL TYPE "B-4"
30 OR 36 INCH LENGTH OF BED



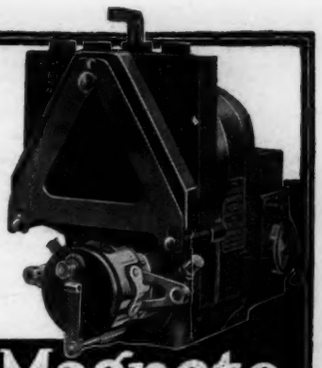
MANUFACTURED BY
DALTON MANUFACTURING CORPORATION
NEW YORK U.S.A. CABLE ADDRESS "ALEDAL" NEW YORK

ENGINEERS

Airdromes—Fields, Equipment, Operation.
Aircraft—Design, Construction.
Aerial Transportation.

United Aircraft Engineering Corporation
52 Vanderbilt Avenue
New York

Half of the American airmen have proved the Berling's worth.



Berling Magneto
WORTH MORE DOES MORE

ROEBLING

AIRCRAFT WIRE
STRAND AND CORD. THIMBLES AND FERRULES

JOHN A. ROEBLING'S SONS COMPANY
TRENTON, NEW JE RSEY

ROEBLING

Grand Rapids Vapor Kilns

are used by these aircraft concerns with absolute satisfaction.

Standard Aircraft Corporation
Fisher Body Corporation,
American Propeller & Mfg Co.
Alexandria Aircraft Corp.,
Gallaudet Aircraft Corp.
Thomas-Morse Aircraft Corp.

Submit your drying problem to experts who make a specialty of kiln design and are prepared to furnish and install all equipment and instruments.

GRAND RAPIDS VENEER WORKS
Grand Rapids, Michigan Seattle, Washington

NEW AND USED AIRPLANES AND MOTORS

Offer, among others, the following Seaplanes and Flying Boats
Curtiss JN4 Seaplane
Thomas Seaplane
Standard Seaplane
Aeromarine Seaplane
Curtiss Flying Boat
Thomas Flying Boat
USAC twin motored 4 passenger flying boat and others

Land machines — Aeronautical motors
Tractor biplanes — 30 to 300 HP.

Send for lists "AN" — *State your needs*

Cable Address: USAE, New York
Long Distance Phone: Cortlandt 449

U.S. AERO EXCHANGE 38 PARK ROW NEW YORK CITY

LEARN TO FLY

in old established school, under an instructor who has given instruction to more

AMERICAN ACES

than any other instructor.

Army Training Planes Used.
We Build Our Machines.

PRINCETON FLYING CLUB, Princeton, N. J.
WEST VIRGINIA AIRCRAFT CO., Wheeling, W. Va.
DAYTONA FLYING CLUB (Winter), Daytona, Fla.

D'Orcy's Airship Manual

"A singularly timely and useful work, which does for the aerial navies of the world something like what Brassey's Annual does for the marine fleets."—*New York Tribune, June* 8, 1918.

$4.00

THE GARDNER-MOFFAT CO., INC.
22 East 17th Street New York

EVERY Liberty Aircraft Engine built is equipped with Zenith Liberty Carburetors—*the reason is clear to Zenith users.*

Zenith Carburetor Co.
New York DETROIT Chicago

PIONEER AIRCRAFT COMPASS

ACCURATE
RELIABLE
HIGH DIRECTIVE FORCE . . . .
LIGHT WEIGHT

WRITE FOR INFORMATION

PIONEER INSTRUMENT COMPANY
380 CANAL ST. N.Y.

DOEHLER
BABBITT-LINED BRONZE
BEARINGS

have been used for years with the utmost success by the leading motor manufacturers in the automobile and airplane industries.

DOEHLER DIE-CASTING CO.

MAIN OFFICE AND EASTERN PLANT
BROOKLYN, N.Y.
WESTERN PLANT TOLEDO, OHIO. NEW JERSEY PLANT NEWARK, N.J.

Also Die-Cast Babbitt Bearings, Die-Castings in Brass & Bronze Aluminum and White Metal Alloys

"EMAILLITE"

Five Dollars a Gallon

The Premier French "Cellulose Acetate" Airplane Dope

Manufactured by the

AMERICAN EMAILLITE COMPANY
549 West Washington Street, Chicago, Illinois.

For Your Flying ←Boats Use

Upward of 5,000 gallons of Jeffery's Patent Waterproof Liquid Glue has been used by the U. S. Navy and War Departments during the past year, and as much more by the various manufacturers of seaplanes having government contracts.

L. W. Ferdinand & Co.
152 Kneeland Street
Boston, Mass., U. S. A.

CAPITAL INTERNAL GRINDER **STAMPINGS** JIGS TOOLS DIES

WE realize *in air* or *at sea* there should be *no faulty* material. All machine parts must be made *right* and perform their functions *properly*, hence we have equipped our new plant to turn out work of the highest quality. We offer our facilities to you and trust we may be of service.

Will you give us a trial?

LANSING STAMPING & TOOL CO.
LANSING, MICHIGAN

PIONEERS IN THE MANUFACTURE OF PROPELLERS

Established 1910 *Formerly Excelsior Prop. Co.*

We carry a large variety of propellers in stock. (No rejects.)
Contractors to United States Government.

Flottorp Manufacturing Co.
AIRCRAFT PROPELLERS
Established 1912

213 Lyon St., Grand Rapids, Michigan

Contractors to United States Government

New York Flying School
A LIMITED NUMBER
OF
SELECT STUDENTS

are being enrolled for tuition at the above school situated within 30 minutes of Times Square (in New York State) under the instruction of American "Aces" and retired service instructors using modern military training 'planes. EVERY BRANCH of aeronautics, from ground mechanics to Cross Country flying with map and compass will be included in the course.

COMPLETE COURSE

including all flights for Civilian License $500.00 with no charge for breakage.

For further particulars, apply by mail to
D. I. LAMB (lately Military Aviator)
11 East 38th Street New York City

INDEX TO ADVERTISERS

A

Aeromarine Plane & Motor Co. 615
Aircraft Engineering Corp. 617
Aldgate Casein Works. 650
Aluminum Castings Co. 619
Aluminum Co. of America. 653
American Emaillite Co. 665
American Propeller & Mfg. Co. 648
Atlas Wheel Co. 647

B

Baker Castor Oil Co. 654
Beardmore & Co., Ltd., William. 616
Boeing Airplane Co. 647
Boston Auto Gage Co. 653

C

Curtiss Aeroplane & Motor Corp. 645

D

Dalton Manufacturing Corp. 654
Dayton Engineering Laboratories Cos. 659
Dixon Crucible Co., Joseph. 652
Doehler Die-Casting Co. 656

E

Eriesson Manufacturing Co. 655
Erie Specialty Co. 652

F

Ferdinand Co., L. W. 656
Flottorp Mfg. Co. 656
Foster and Stewart Co. 620
Fox Machine Co. 651
Foxboro Co., The. 653

G

Goodyear Tire & Rubber Co. 658
Grand Rapids Veneer Works. 655

J

Johns-Manville Co., H. W. 652

L

L-W-F Engineering Co., Inc. 650
Lansing Stamping & Tool Co. 656
Lewis and Vought Corp. 651

M

Martin Co., The Glenn L. 614
Maryland Pressed Steel Co. 646
Merchants Fire Assurance Corp. of N. Y. 649
Multnomah Lumber & Box Co. 654

N

New Departure Mfg. Co. 622
New York Flying School. 656
Nieuwhof, Surie & Co. 650
Norma Co. of America. 620

P

Park Drop Forge Co. 648
Pioneer Instrument Co. 656
Princeton Flying Club. 655

R

Roebling, John A., Sons' Co. 655
Rolls-Royce, Ltd. 618

S

Safety-at-Sea Corp. 652
Stimpson, Edwin B. 653
Stone Propeller Co. 656
Sturtevant, The B. F. Co. 646

T

Thomas-Morse Aircraft Corp. 649

U

United Aircraft Engineering Corp. 655
U. S. Aero Exchange. 655
U. S. Rubber Co. 660

V

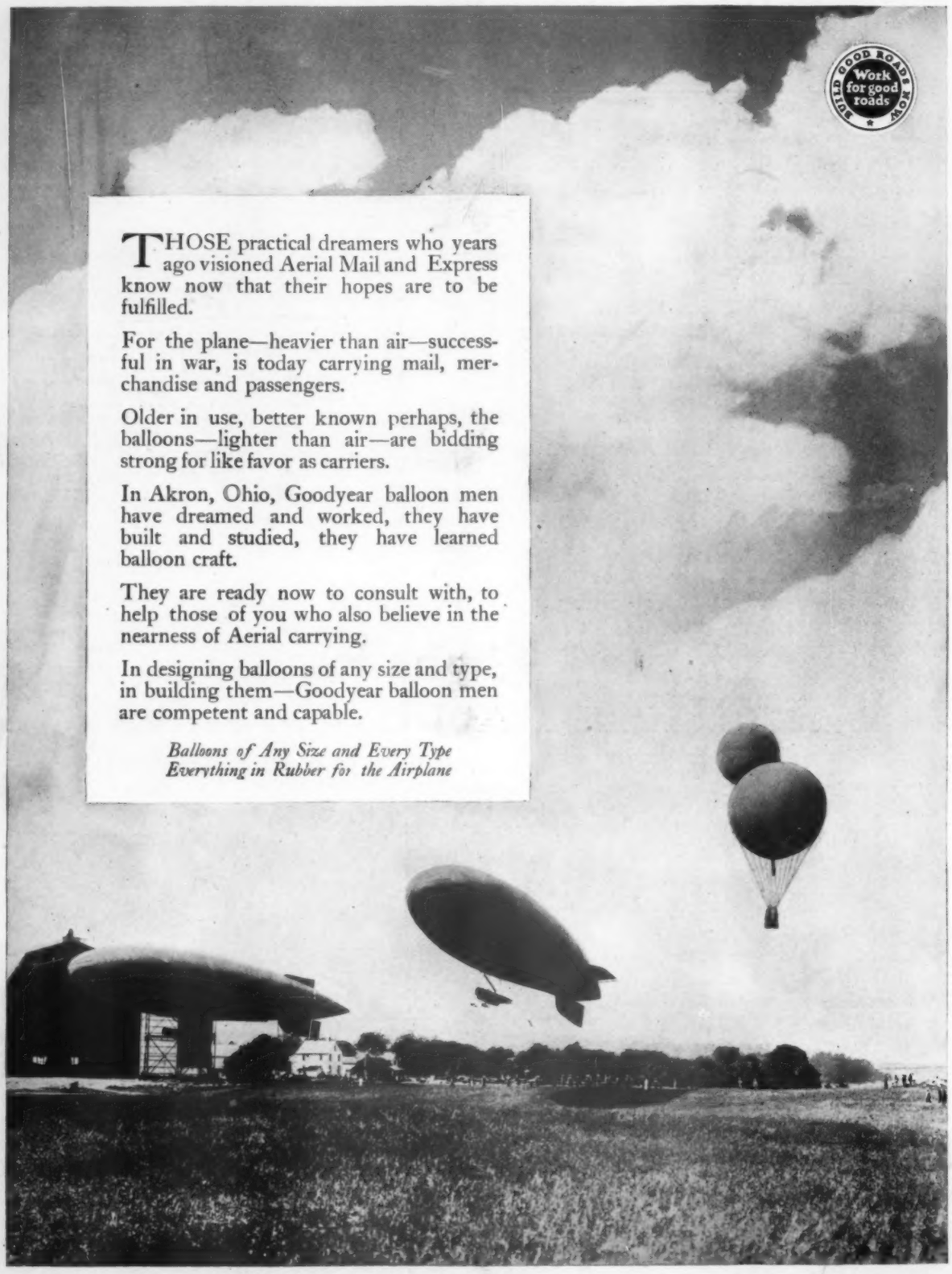
Veeder Mfg. Co., The. 651

W

West Virginia Aircraft Co. 655
Wittemann-Lewis Aircraft Co. 654
Wyman-Gordon Co. 621

Z

Zenith Carburetor Co. 655



THOSE practical dreamers who years ago visioned Aerial Mail and Express know now that their hopes are to be fulfilled.

For the plane—heavier than air—successful in war, is today carrying mail, merchandise and passengers.

Older in use, better known perhaps, the balloons—lighter than air—are bidding strong for like favor as carriers.

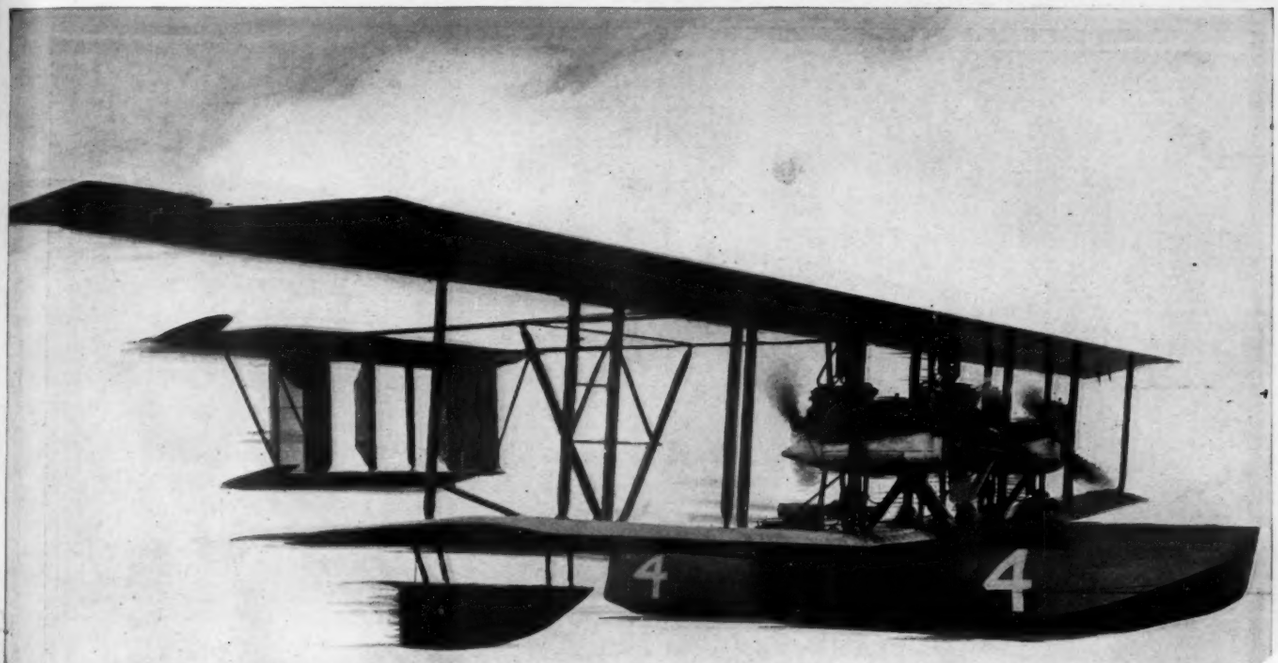
In Akron, Ohio, Goodyear balloon men have dreamed and worked, they have built and studied, they have learned balloon craft.

They are ready now to consult with, to help those of you who also believe in the nearness of Aerial carrying.

In designing balloons of any size and type, in building them—Goodyear balloon men are competent and capable.

Balloons of Any Size and Every Type
Everything in Rubber for the Airplane

GOODYEAR
AKRON

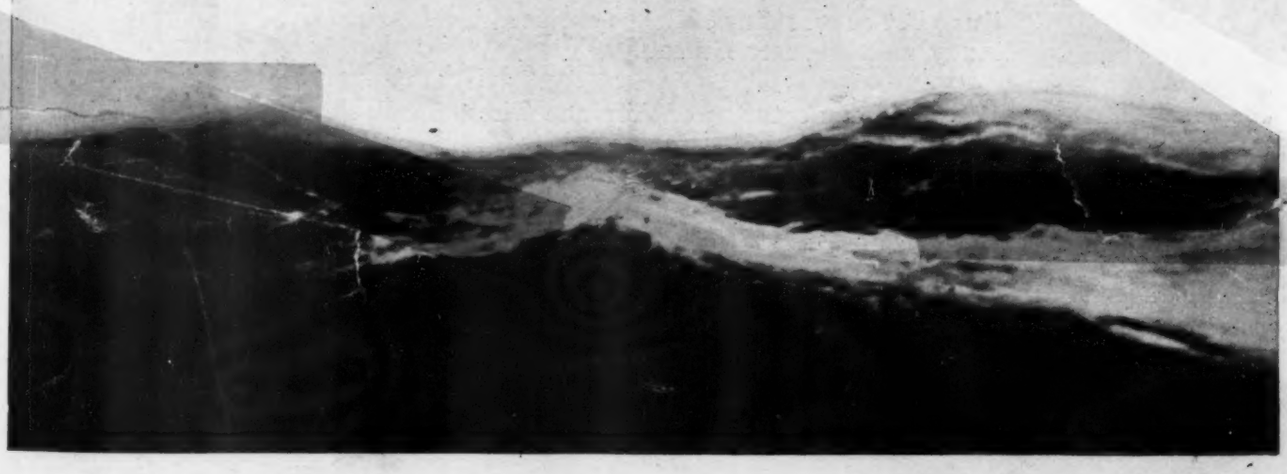


NC-4 Flight Proved American Inventive Geni

"The engines functioned perfectly all the way from America to Portugal."
-Lieutenant Commander Read,
Commanding NC-4

Liberty Motor - Delco-equipp

THE DAYTON ENGINEERING LABORATORIES COMPANY, DAYTON OHIO,



United States Balloon Fabrics

UPON the fabric depends the entire service of the balloon. United States Balloon Fabrics have established an unquestioned reputation for that high quality which is absolutely essential in the choice of such materials.

We are prepared to supply everything in the line of balloon fabrics; double and single ply, bias and parallel, used and approved by the Bureau of Aircraft Production of the United States Government at Washington.

Our pilot or sounding balloons are used by the Army, Navy and Weather Bureau.

We are manufacturers of Airplane Tires, Shock Absorbers, Gasoline and Radiator Hose, Rubber Matting, and Shoes for Aviators.

United States Rubber Company

3680